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*for* Diane Earp
Principal Investigator

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# Health Care Environment Simulation
# for the
# Unit Cell Concept
# Phase I

## Abstract

The Phase I Health Care Environment Simulation (HCES) effort provides a proof of concept model that can support a high-level Unit Cell Concept configuration of the current health care system's primary elements. The five medical components specified as key elements of the system (Clinic, Primary Care Physician Office, Community Hospital, Regional Medical Center, and Diagnostic Treatment Center) have been distinctly modeled. The model represents the overall health care entities in an integrated system. Five medical conditions composing a total of 13 test cases are used to exercise the model during Phase I. Analysis of the Unit Cell versus the current health care system is supported by model runs based upon a synthetic population and national statistical data. Phase I analyses support our theories that the Unit Cell Concept will reduce costs, improve overall quality, and ensure accessibility of/to the existing health care system. This will be accomplished primarily as a result of the impact to infrastructure and the application of advanced technology.

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# Section 1: Introduction

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## UNIT CELL CONCEPT

A Unit Cell is a region defined by common characteristics, culture, professional relationships, an/or economics experiencing similar health care problems, such that solutions are applied uniformly to all the cell's constituents. The key point is that any applied solution's goal brings the health care standards of the entire cell to parity of the same standards of the highest quality available. The primary elements of a Unit Cell are one or more regional medical centers, community hospitals, clinics, physician offices, third party payers, community leaders, business leaders, and the health care providers associated with all of these operations. An operational Unit Cell facilitates interaction between all health care elements of a region to provide the highest quality of care to all its citizens at the lowest possible cost through operational process adjustments and infrastructure design, facilitated by existing and futuristic technological capabilities.

## SIMULATION OVERVIEW

Simulation has become an integral part of end-to-end systems engineering process. System models support architecture evaluation and selection, plug and play capability, and changes to loads on existing systems. Our team has developed models in support of an array of varying applications including processing, exploitation, dissemination, communication, and process re-engineering systems.

Our team has developed a comprehensive modeling environment, consisting of proprietary software layered upon commercially available modeling tools, that allows us to model new applications very rapidly. Architectures are simulated using a growing library of component models that represent critical system components. The components are configured via input parameters and interfaced according to the characteristics topology of each candidate system. Simulated work flow is based upon characteristics of these components in relation to the operational concept, the software control architecture, and resource requirements of the system algorithms.

When the results of valid benchmarking are incorporated, the simulation provides meaningful predictions of resource utilization, queue dynamics, timeline performance, and system throughput.

## PHASE I ACTIVITIES -- Applying Simulation Techniques To The Unit Cell Concept

The E-Systems System Simulation Group and Booz-Allen, Hamilton Simulation Group are currently in the midst of an ongoing effort to jointly produce a health care environment model in order to evaluate the E-Systems Unit Cell concept's impact on the health care system.

The Phase I HCES model effort provides a proof of concept model that is able to support a current and future configuration of the health care system. In Phase I the two groups worked independently using distinct modelling tools in order to validate findings. One model focuses on detailed trajectory of patients through the health care system while the other model analyzes resource utilization across wide populations thereby addressing more global issues. Examples of the current configuration, future configuration, and the model components are discussed in detail in Section 3.

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A significant goal in Phase I is to provide the initial simulation framework for analyzing the differences between the current health care environment and the proposed impact of the Unit Cell Concept on that environment. The Phase I version of the HCES model has successfully culminated with this framework well underway. Additionally, the following goals have been met upon completion of Phase I activities:

- **Deliverables Completed**

  The deliverables specified in the Statement Of Work are the resultant outputs of the model. These measured outcomes are derived from the interactions of a synthetic population and five medical components: the Clinic, Primary Care Physician Office, Community Hospital, Regional Medical Center, and Diagnostic Treatment Center. Each has been distinctly modeled at an appropriate level of detail for Phase I.

- **Medical Facility Models Integrated**

  The facilities modeled during the progression of Phase I have been integrated into a single, functional model representing a theoretical Unit Cell. Because the success of Phase I hinges on modelling the current health care environment and thus the Unit Cell Concept's "Proof of Concept", the model exhibits a high level framework for the simulation of the internals of each medical facility individually as well as collectively as a single entity. The high level routing control is managed by the *System Routing* submodel which allows for systematic patient trajectory across facility boundaries. In essence, this captures the root-level requirement of establishing the Phase I model as a building-block for future HCES modeling activities. The flexibility embraced in the design allows for intra-facility models, and more importantly, facility to facility type of connectivity simulating real world inter-facility relationships.

- **Scenario Generation Capability Developed**

  During the course of Phase I, an effort has been made to develop software to support model tasking. This allows the HCES model to be exercised by injecting patients as transactions. Development of this capability allows for freedom of the model itself from the details of how patients are created as well as patient attributes, thus decoupling scenario generation from scenario processing. This will be advantageous during ongoing HCES modeling activities due to improved run-time performance, especially with respect to very large scenarios (high volume of patients and/or lengthy time period simulated). Additionally, the scenario generator capability is "open", meaning that as specific patient attributes and demographics are realized for a given Unit Cell, these can be folded into the scenario with only minor changes to scenario files and code.

- **Five Medical Conditions Modeled**

  Five medical conditions are examined in the Phase I model including Pneumococcal Pneumonia, RSV Pneumonia, Myocardial Infarction, Hypertension, and Influenza. Numerous scenarios of patient behavior and protocols for diagnosis and treatment exist for each medical condition. To ensure the successful completion of Phase I, only three case studies were examined for each of the five medical conditions modeled. An assumption of homogeneity of both physician and patient exists to support the feasibility of this task.

- **Condition-Specific Health Care Rules Implemented**

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A health care rule database approach has been implemented for Phase I. Specific health care rules associated with the diagnostics, treatments, administrative necessities, and typical progression of disease were folded into a common database and extracted as patients with these conditions were introduced into the model. This approach allowed the specific aspects of the model to be analyzed including model topology and cost breakdown.

- **Key Model Components Highly Parameterized and "Open"**

  A major goal of the Phase I activity was the assurance that the model was developed to maximize flexibility and reusability. This is demonstrated by highly parameterized facility submodels which allow for timely customization such as facility configuration or cost of services provided. Similarly, the model has been designed to allow for multiple instances of the same flavor of facility (i.e. "N" physician offices within a Unit Cell) all of which utilize the same core code, but which may be parameterized and configured to reflect vastly different facilities. Preservation of this type of flexibility ensures that the core "engine" of the HCES model will remain essentially intact as the model is used to examine multiple Unit Cells. Minimizing custom code changes in this way reduces potential bugs introduced when attempting to configure the model for a new Unit Cell and also reduces turn around time when a change is requested.

- **Interdisciplinary Education**

  Certainly one of the most important issues and goals of Phase I has been the two-way interdisciplinary education that has indeed occurred by the members of the team. Although this is not a deliverable and cannot be quantitatively measured, it is certainly a critical element in the continued success of the HCES modeling effort. Bridging this gap is definitely no small task, thus will continue to be a major effort in the upcoming phases of this project.

As Phase I is now completed, we feel confident in having met the deliverables and having established a modeling framework that is open, flexible, and integrated. This model has been exercised via scenarios representing a synthetic population with success. For these reasons, we feel that it is positioned to proceed into Phase II activities, and face the challenging task of applying the model to a specific Unit Cell. The remainder of this document addresses the specifics of phase I development activities as well as other health care specific information that was used during Phase I.

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# Section 2: Definitions

## 2.1 Section Overview

This section of the Unit Cell Model document focuses on terminology. The term included here are important in understanding some of the Phase I concepts that are covered throughout the remainder of the document. In some cases, the term is accompanied by its associated acronym, which is used for reference in the document.

## 2.2 Common Terms

### 2.2.1 Apparent Symptoms
Symptoms that are noticeable by the patient.

### 2.2.2 Cardiac Care Unit Room and Board
Cardiac care required for patient; 24-hour-a-day monitoring and/or treatment.

### 2.2.3 Clinic Visit
Patient visits clinic for medical care.

### 2.2.4 Computerized Medical Records (CMR)
Patient records exchanged among physicians and/or facilities electronically and stored on a shared database system.

### 2.2.5 Economic Costs
Cost associated with the medical condition requiring the patient to take time off from work or school during treatment and recovery.

### 2.2.6 Emergency Room Care
Services provided in an emergency room (ER) for two types of patients. The first type is emergency care required for life-threatening conditions. The second type is care provided to patients who require non-emergency care but enter the system at ER because of lack of insurance or because of no accessibility to low-cost care whether it be due to patient proximity to nearest low-cost care facility or because of the operating business hours of low-cost care facility.

### 2.2.7 Exit System
Patient returns to normal health or dies from the condition.

### 2.2.8 Floor Room and Board
Patient condition that requires monitoring and/or treatment every "n" time units by health care staff (most likely provided in a hospital or medical center but not limited to these facilities in the model).

### 2.2.9 Home Recovery
Patient released to home for recovery but not released by the physician to return to work or school.

### 2.2.10 Intensive Care Unit Room and Board
Constant, uninterrupted care required for patient, including 24-hour-a-day monitoring and/or treat-

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ment.

### 2.2.11 Medical Costs
Cost associated with medical care provided to patient, including physician fees, medications, diagnostics, etc.

### 2.2.12 Normal Health
Two check-ups per year required for patient.

### 2.2.13 Physician Consult/Remote Available in Future Version
Physician required for diagnosis and recommended treatment. Consult can be done remotely if available.

### 2.2.14 Presentation Delay
Time delayed until patient seeks health care after becoming aware of apparent symptoms.

### 2.2.15 Primary Care Hospital Visit
Primary Care Physician required in hospital to provide medical care and/or consultation.

### 2.2.16 Primary Care Office Visit
Patient visits Primary Care Physician Office for medical care.

### 2.2.17 Pulmonary Consult
Pulmonary specialist required for treatment of condition. This is NOT a remote consult.

### 2.2.18 Return to Work
Patient has returned to normal health and is able to fully function at work or school.

### 2.2.19 Specialist Consult/Remote Available in Future Version
Expert Physician/Specialist in field required for diagnosis and recommended treatment. Consult can be done remotely if available.

### 2.2.20 Specialist Hospital Visit
Expert Physician/Specialist required in hospital to provide medical care and/or consultation.

### 2.2.21 Telemedicine
The practice of combining medicine with technology to add the capability of remote diagnosis through the use of image transfers, on-screen communication, etc.

### 2.2.22 Technological Lines of Communication (TLC)
Forms of Telemedicine, Computerized Medical Records, and access to medical library databases.

### 2.2.23 Work Recovery
Patient can return to work or school but requires scheduled visits to a physician for follow-up care during recovery period.

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# Section 3: Patient Conditions

## 3.1 Section Overview

Five patient conditions are represented in the Phase I Unit Cell Simulation Model.

- **Pneumococcal Pneumonia**
  A condition common among the immunosuppressed, the very young, the elderly, the malnourished, and those predisposed to chronic pulmonary conditions.

- **Respiratory Scyntical Virus (RSV) Pneumonia**
  A condition occurring in infants less than 2 years of age.

- **Myocardial Infarction (MI)**
  A heart attack.

- **Hypertension Leading to Hypertensive Crisis**
  A condition common among males over the age of 35. Leading causes are stress, poor diet, and lack of exercise.

- **Influenza**
  A seasonal condition.

For the Phase I study, the three case studies chosen for each condition are classified as a mild, a moderate, or a severe presentation of the condition. The case studies reflect discrete points in time that a homogeneous patient enters the health care system for treatment after observing apparent symptoms. Recall from Section 2.2 that this is referred to as the *presentation delay*. Patients in the Phase I health care system will enter with a mild, moderate, or severe presentation of their respective condition. The case studies modeled for each condition and the protocol for health care for each are described in the following sections. Refer to Appendix A for the data sources used to define the case studies.

## 3.2 Pneumococcal Pneumonia

### 3.3.1 Section Overview
Approximately 3,000,000 known cases per year of pneumococcal pneumonia occur in the United States.

> 40 to 60% had recent respiratory infection as an immediate antecedent (most common is flu) 30% require hospitalization
> 70% either self-resolve or are treated as out-patients
> 80% of all pneumonias requiring hospitalization are pneumococcal (a grouping of bacilli famous for their manifested lung disease)

The probability distribution is normal across the population, but some segments of the population are more normal than others. This group includes alcoholics, homeless people, sedentary elderly,

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immunosuppressed, those with end-stage lung disease (cystic fibrosis, cancer, asthma, chronic bronchitis, etc.) and the very young.

### 3.3.2 Untreated Case

**DAY 1-2:**
**Incubation**

**Day 3-4:**
**Patient Behavior:**
Self-treats at home with aspirin

**Symptoms:**
Mild elevation in temperature (< 101°F)
General malaise

**DAY 5:**
**Symptoms:**
Non-productive or mildly productive cough, purulent sputum, chills and fever, 101°F or higher, some chest tightness and difficulty breathing on exertion, generalized weakness, decreased appetite, decreased fluid intake, tachycardiac

**DAY 6:**
**Symptoms:**
Chills and fever (> 103°F) unresponsive to aspirin, cough productive of purulent or rusty sputum, weakness, stuporous-to-confused mental state, near-absent appetite and fluid intake, difficulty breathing, tachycardiac

**DAY 7:**
**Symptoms:**
Chills and fever (> 104°F) unresponsive to aspirin, labored breathing at rest, cyanotic, confused-to-unconscious mental state, zero appetite, zero fluid intake, cough productive of grossly purulent sputum in large amounts, zero urine output, tachycardiac

**DAY 8:**
**Symptoms:**
Death from respiratory, renal, and cardiac failure

### 3.3.3 Mild Case

**DAY 1-2:**
**Incubation**

**DAY 3:**
**Patient Behavior:**
Patient enters health care system

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**Symptoms:**
Mild elevation in temperature (< 101°F)
General malaise

**Diagnostics:**
CBC
EKG
SMAC 12
Sputum specimen for culture and sensitivity, gram stain
X-ray of chest

**Treatments:**
Antibiotic therapy (x 10 days) starting with an intramuscular injection rehydration

**DAY 4:**
**Patient Behavior:**
Home recovery
Call immediately if condition worsens such as fever continues to climb and remains unresponsive to aspirin.
f/u visit in 48 hours

**Symptoms:**
Fever 100-101°F
Generalized weakness
Cough continues to be productive
Breathing more easily

**Diagnostics:**

**Treatments:**
Continue home recovery and therapy

**DAY 5 -- DAY 13:**
**Patient Behavior:**
Calls or visits to learn results of sputum culture and to either confirm current antibiotic is correct or change it from broad spectrum to something more specific

**Symptoms:**
Coughing diminishes, then disappears
Strength returns to normal
Fever diminishes

**Diagnostics:**
**Treatments:**
Continue home recovery and therapy

**DAY 14:**
**Patient Behavior:**
Return to Work
Exit system

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### 3.3.4 Moderate Case

**DAY 1 - 2:**
Incubation

**DAY 3:**
**Patient Behavior:**
Home treatment

**DAY 4:**
**Patient Behavior:**
Patient enters health care system

**Symptoms:**
Non-productive or mildly productive cough, purulent sputum, chills and fever,101°F or higher, some chest tightness and difficulty breathing on exertion, generalized weakness, decreased appetite, decreased fluid intake, tachycardiac.

**Diagnostics:**
X-ray of chest
CBC
SMAC 12
EKG
Sputum specimen for culture and sensitivity, gram stain
Culture
O2 spot check

**Treatments:**
Antibiotic therapy (x 10 days) starting with IV's now
Rehydration
Oxygen

**DAY 5- DAY 6:**
**Symptoms:**
Breathing improved
More alert but still weak
Cough productive
Fever around 100°F

**Diagnostics:**
X-ray of chest
CBC
SMAC 12
EKG
Sputum specimen for culture and sensitivity, gram stain
Culture
Monitor
Oxygen saturation

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**Treatments:**
Antibiotic
Rehydration
Respiratory therapy (breathing treatments every 4 hours) to help open lung and improve effectiveness of cough
Floor room and board
Oxygen

**DAY 7 -- DAY 16:**
**Patient Behavior:**
Home Recovery
Follow-up visit in 48 hours

**Symptoms:**

**Diagnostics:**

**Treatments:**
Complete entire antibiotic regimen
Maintain fluid and nutritional intake

**DAY 16:**
**Patient Behavior:**
Return to work
Full recovery - Exit system

### 3.3.5 Severe Case

**DAY 1 - 2:**
Incubation

**DAY 3 - 4:**
**Patient Behavior:**
Home treatment

**DAY 5:**
**Patient Behavior:**
Patient enters health care system at Emergency Room
Patient admitted to floor

**Symptoms:**
Unconscious
Near respiratory and cardiac failure

**Diagnostics / Diagnosis:**
X-ray of chest
ABG
CBC
SMAC 12
EKG

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Sputum specimen for culture and sensitivity, gram stain
Culture
Monitor
Oxygen saturation

**Treatments:**
Antibiotic therapy (x 10 days) staring with iv's now
Begin aggressive respiratory therapy every 1-2 hours
Begin nutritional support by IV
Fluid and electrolyte maintenance
Oxygen
ICU room and board

**DAY 6:**
**Symptoms:**

Fever (> 102°F)
Unconscious
Cough continues productive of purulent secretions in gross amounts
Breathing remains labored

**Diagnostics:**
Repeat all diagnostics

**Treatments:**
Continue all therapy
ICU room and board

**DAY 7 -- DAY 13:**
**Symptoms:**
Coughing continues as pneumonia worsens
Fever continues

**Diagnostics/Diagnosis:**
Repeat all diagnostics
Death occurs on day 13 from cardiac failure

**Treatments:**
Continue all therapy
ICU room and board

**DAY 13:**
**Patient Behavior:**
Full recovery - exit system

## 3.3 RSV Pneumonia

### 3.3.1 Section Overview
This specific type of pneumonia which strikes infants under the age of 2 years, has early symptoms similar to the flu.

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### 3.3.2 Untreated Case

**DAY 1-2:**
**Incubation**

**Day 3-4:**
**Patient Behavior:**
    Self-treats at home with aspirin

**Symptoms:**
    Mild elevation in temperature (< 101°F)
    General malaise

**DAY 5:**
**Symptoms:**
    Non-productive or mildly productive cough, purulent sputum, chills and fever 101°F or higher, some chest tightness and difficulty breathing on exertion, generalized weakness, decreased appetite, decreased fluid intake, tachycardiac

**DAY 6:**
**Symptoms:**
    Chills and fever (> 103°F) unresponsive to aspirin, cough productive of purulent or rusty sputum, weakness, stuporous-to-confused mental state, near absent appetite and fluid intake, difficulty breathing, tachycardiac

**DAY 7:**
**Symptoms:**
    Chills and fever (> 104°F) unresponsive to aspirin, labored breathing at rest, cyanotic, confused-to-unconscious mental state, zero appetite, zero fluid intake, cough productive of grossly purulent sputum in large amounts, zero urine output, tachycardiac

**DAY 8:**
**Symptoms:**
    Death from respiratory, renal, and cardiac failure

### 3.3.3 Mild Case

**DAY 1-2:**
**Incubation**

**DAY 3:**
**Patient Behavior:**
    Patient enters health care system

**Symptoms:**
    Mild elevation in temperature (< 101°F)
    General malaise

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**Diagnostics:**
  X-ray of chest
  CBC
  SMAC 12
  O2 spot check
  Sputum specimen for culture and sensitivity, gram stain
  Culture

**Treatments:**
  None

**DAY 4:**
**Patient Behavior:**
  Patient admitted to hospital

**Symptoms:**
  Fever (100-101°F)
  Generalized weakness
  Cough continues to be productive
  Breathing more easily

**Diagnostics:**
  X-ray of chest
  CBC
  SMAC 12
  Sputum specimen for culture and sensitivity, gram stain
  Culture
  Monitor
  Oxygen saturation

**Treatments:**
  Antibiotic
  Rehydration
  Oxygen
  Respiratory therapy

**DAY 5-7:**
**Patient Behavior:**

**Symptoms:**

**Diagnostics:**
  X-ray of chest
  CBC
  SMAC 12
  Sputum specimen for culture and sensitivity, gram stain
  Culture
  Monitor
  Oxygen saturation

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**Treatments:**
> Rehydration
> Antiviral
> Oxygen
> Floor room and board

**DAY 8- 9:**
**Patient Behavior:**
> Home recovery

**Symptoms:**

**Diagnostics:**

**Treatments:**

**DAY 10:**
**Patient Behavior:**
> Return to work
> Full recovery - exit system

### 3.3.4 Moderate Case

**DAY 1-2:**
**Incubation**

**DAY 3:**
**Patient Behavior:**
> Home treatment

**DAY 4:**
**Patient Behavior:**
> Patient enters health care system

**Symptoms:**
> Non-productive or mildly productive cough, purulent sputum, chills and fever, 101F or higher, some chest tightness and difficulty breathing on exertion, generalized weakness, decreased appetite, decreased fluid intake, tachycardiac

**Diagnostics:**
> X-ray of chest
> CBC
> SMAC 12
> Sputum specimen for culture and sensitivity, gram stain
> Culture
> Monitor
> Oxygen saturation

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**Treatments:**
  Antibiotic therapy (x 10 days) starting with IV's now
  Rehydration
  Respiratory therapy
  Oxygen
  Floor room and board

**DAY 5 - 7:**
**Symptoms:**
  Breathing improved
  More alert but still weak
  Cough productive
  Fever around 100°F

**Diagnostics:**
  CXR
  CBC
  SMAC 12
  Sputum specimen for culture and sensitivity, gram stain
  Culture
  Monitor
  Oxygen saturation

**Treatments:**
  Antiviral
  Rehydration
  Respiratory therapy (breathing treatments every 4 hours) to help open lungs and improve
  effectiveness of cough
  Oxygen
  ICU room and board

**DAY 8 - 10:**
**Symptoms:**

**Diagnostics:**
  All diagnostics repeated
  On day 10, no need for oxygen saturation

**Treatments:**
  All treatments repeated
  Patient is transferred out of ICU to floor

**DAY 11 - 14:**
**Patient Behavior:**
  Home recovery
**Symptoms:**

**Diagnostics:**

**Treatments:**

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**DAY 14:**
**Patient Behavior:**
    Return to work
    Full recovery - exit system

### 3.3.5 Severe Case

**DAY 1 - 2:**
**Incubation**

**DAY 3 - 4:**
**Patient Behavior:**
    Home treatment

**DAY 5:**
**Patient Behavior:**
    Patient enters health care system and is admitted to ICU

**Symptoms:**
    Non-productive or mildly productive cough, purulent sputum, chills and fever, 101°F or
    higher, some chest tightness and difficulty breathing on exertion, generalized weakness,
    decreased appetite, decreased fluid intake, tachycardiac

**Diagnostics:**
    X-ray of chest
    CBC
    SMAC 12
    EKG
    Sputum specimen for culture and sensitivity, gram stain
    Culture
    Monitor
    Oxygen saturation

**Treatments:**
    Antibiotic
    Rehydration
    Respiratory therapy (breathing treatments every 4 hours) to help open lungs and improve
    effectiveness of cough
    Oxygen
    ICU room and board

**DAY 6-9:**
**Symptoms:**
    Fever (> 102°F)
    Unconscious
    Cough continues productive of purulent secretions in gross amounts
    Breathing remains labored

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**Diagnostics:**
    Repeat all diagnostics except EKG

**Treatments:**
    Continue all therapy
    ICU room and board

**DAY 9:**
**Patient Behavior:**
    Patient dies on day 9 from cardiac failure
    Exit system

## 3.4 Myocardial Infarction

### 3.4.1 Section Overview

### 3.4.2 Untreated Case

### 3.4.3 Mild Case

**DAY 1:**
**Patient Behavior:**
    Patient enters health care system at Emergency Room

**Symptoms:**
    Complains of (C/O) chest pain (angina) radiating to left arm x 1 hours, vice-like tightness
    in chest, diaphoretic, pale, short of breath (SOB), "feels like indigestion"

**Diagnostics/Diagnosis:**
    ABG
    Cardiac enzymes
    CBC
    SMAC 18
    CXR
    ECHO
    EKG
    Oxygen saturation
    Liver function
    Hemoglobin (HGB)
    Hematocrit (HCT)

**Treatments:**
    IV
    Oxygen supplement
    Stabilized then taken to Cardiac Care Unit (CCU)

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**DAY 2-3:**
**Symptoms:**

**Diagnostics/Diagnosis:**
　　All diagnostics repeated

**Treatments:**
　　CCU room and board
　　IV
　　Oxygen
　　Smoking counseling
　　Weight Loss counseling
　　Stress management counseling
　　Nutrition counseling

　　Goals of therapy:
　　1) Re-establish and maintain homeostasis.
　　2) Wean off IV.
　　3) Identify a drug regimen that will control any arrhythmias and elevated blood pressure (BP).
　　4) Provide physical therapy to prevent loss of muscle tone and to help patient overcome the anxiety associated with physical exertion common among heart attack victims.
　　5) Provide supportive counseling to help eliminate or minimize any contributing risk factors such as smoking, alcohol, obesity, sedentary life style, lowering cholesterol as quickly as possible.

**DAY 4:**
**Patient Behavior:**
　　Home recovery
　　Return in 48 hours for follow-up.

**Symptoms:**

**Diagnostics/Diagnosis:**
　　All diagnostics repeated except for ECHO

**Treatments:**
　　Discharged
　　Follow-up visit to doctors office in 2 days

**DAY 21:**
**Patient Behavior:**
　　Return to work

**DAY 6, 13, 20, 27:**
**Patient Behavior:**
　　Regular visit

**Symptoms:**
**Diagnostics/Diagnosis:**
**Treatments:**

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**DAY 57:**
**Patient Behavior:**
Visit Physician Office for stress test

**Symptoms:**

**Diagnostics/Diagnosis:**
Stress test

**Treatments:**

**DAY 87, 177, 267, 357, 447:**
**Patient Behavior:**
Regular visit

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

**DAY 448:**
**Patient Behavior:**
Exit system

## 3.4.4 Moderate Case

**DAY 1:**
**Patient Behavior:**
Patient enters health care system at Emergency Room

**Symptoms:**
Complains of chest pain (angina) radiating to left arm x 1 hours, vice-like tightness in chest, diaphoretic, pale, short of breath, "feels like indigestion"

**Diagnostics/Diagnosis:**
ABG
Cardiac enzymes
CBC
SMAC 18
CXR
Echocardiogram
EKG
Oxygen saturation
Liver function
Hemoglobin (HGB)
Hematocrit (HCT)

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**Treatments:**
    IV
    Oxygen supplement
    Stabilized then taken to CCU

**DAY 2:**
**Symptoms:**

**Diagnostics/Diagnosis:**
    All diagnostics repeated

**Treatments:**
    CCU room andbBoard
    IV
    Oxygen
    Smoking counseling
    Weight loss counseling
    Stress management counseling
    Nutrition counseling

Goals of therapy:
1) Re-establish and maintain homeostasis.
2) Wean off IV.
3) Identify a drug regimen that will control any arrhythmias and elevated BP.
4) Provide physical therapy to prevent loss of muscle tone and to help patient overcome the anxiety associated with physical exertion common among heart attack victims.
5) Provide supportive counseling to help eliminate or minimize any contributing risk factors such as smoking, alcohol, obesity, sedentary life style, lowering cholesterol as quickly as possible.

**DAY 3:**
**Symptoms:**

**Diagnostics/Diagnosis:**
    All diagnostics repeated

**Treatments:**
    CCU room and board
    IV
    Oxygen
    Ventilation
    Pulmonary donsult

**DAY 4 - 6:**
**Symptoms:**

**Diagnostics/Diagnosis:**
    All diagnostics repeated

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**Treatments:**
>     CCU
>     All treatments continued
>     On day 6, patient is taken off ventilation

**DAY 7 - 8:**
**Symptoms:**

**Diagnostics/Diagnosis:**
>     All diagnostics repeated except for ECHO

**Treatments:**
>     CCU room and board
>     IV
>     Oxygen
>     Smoking counseling
>     Weight loss counseling
>     Stress management counseling
>     Nutrition counseling

**DAY 9:**
**Patient Behavior:**
>     Home recovery
>     Return for follow-up in 48 hours

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

**DAY 11, 18, 25:**
**Patient Behavior:**
>     Regular visit

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

**DAY 26:**
**Patient Behavior:**
>     Return to work

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

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**DAY 32:**
**Patient Behavior:**
   Regular visit

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

**DAY 62:**
**Patient Behavior:**
   Visit Physician Office for stress test

**Symptoms:**

**Diagnostics/Diagnosis:**
   Stress test

**Treatments:**

**DAY 97, 187, 277, 367, 457:**
**Patient Behavior:**
   Regular visit

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

**DAY 458:**
**Patient Behavior:**
   Exit System

**3.4.5  Severe Case**

**DAY 1:**
**Patient Behavior:**
   Patient enters health care system at Emergency Room

**Symptoms:**
   Complains of chest pain radiating to left arm x 1 hours, vice-like tightness in chest, dia-
   phoretic, pale, short of breath, "feels like indigestion"

**Diagnostics/Diagnosis:**
   ABG
   Cardiac enzymes

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CBC
SMAC 18
Chest X-ray (CXR)
Echocardiogram
EKG
Oxygen saturation
Liver function
Hemoglobin (HGB)
Hematocrit (HCT)

**Treatments:**
IV
Oxygen supplement
Ventilation
Emergency room care
Stabilized then taken to CCU
Pulmonary consult

**DAY 2 - 10:**
**Symptoms:**

**Diagnostics/Diagnosis:**
All diagnostics repeated

**Treatments:**
All treatments continued in CCU

**DAY 11 - 13:**
**Symptoms:**

**Diagnostics/Diagnosis:**
All diagnostics repeated

**Treatments:**
CCU room and board
IV
Oxygen
Smoking counseling
Weight loss counseling
Stress management counseling
Nutrition counseling

**DAY 14:**
**Patient Behavior:**
Home Recovery
Follow-up visit in 48 hours

**Symptoms:**
**Diagnostics/Diagnosis:**
**Treatments:**

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**DAY 16, 23, 30, 37:**
**Patient Behavior:**
Regular visit

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

**DAY 38:**
**Patient Behavior:**
Return to work

**DAY 67:**
**Patient Behavior:**
Visit Physician Office for stress test

**Symptoms:**

**Diagnostics/Diagnosis:**
Stress test

**Treatments:**

**DAY 102, 192, 282, 372, 462:**
**Patient Behavior:**
Regular visit

**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**

**DAY 463:**
**Patient Behavior:**
Exit system

## 3.5 Hypertension

### 3.5.1 Section Overview

Gestation occurs across years and is symptomless until a hypertensive episode occurs. The outcome depends upon race, sex, age, degree of hypertension, availability of appropriate health care, smoking, percent of ideal body weight, level of exercise, salt intake, cholesterol, and level of stress.

People can live with hypertension for years before they develop any outward symptoms. Untreated high blood pressure can result in death at any level but does so most frequently when it exceeds the

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210/130 range and stays there. This is called malignant hypertension and untreated results in death in 6 months to 1 year. The final hours of a patient with untreated hypertensive are spent in hypertensive crisis. Authorities disagree as to the exact range, but most agree that a person with a BP > 240/140 will die in hours if not treated.

There appears to be a pattern of disease progression from borderline to mild, moderate, and then severe hypertension related to the patient's age. As the patient ages, the blood pressure rises in a linear fashion, although this is not absolute. Some patients graduate from mild to severe in one jump. The best approach would be to distribute the population of hypertensive patients across the five stages of treatment, dividing them into five age brackets:

> 25 to 34 stage 1   3% of all morbid events
> 35 to 44 stage 2   7% of all morbid events
> 45 to 54 stage 3   10% of all morbid events
> 55 to 64 stage 4   35% of all morbid events
> \> 65 stage 5       45% of all morbid events

Morbid events include cerebrovascular accidents (CVA's), hypertensive encephalopathy, renal failure, myocardial infarctions (MI's), abdominal aortic aneurysms (AAA's), and aortic dissections (a tear in the innermost of the three cellular layers comprising the arterial wall).

It is difficult to say how many cases exist exactly. A safe bet would be that the number of known cases represents roughly 50 percent of all cases below the age of 45 and 85 percent of all cases above that age.

### 3.5.2 Untreated Case

**DAY 1:**
**Symptoms:**
> Blood pressure shifts from normal to borderline
> Symptomless without complications

**YEARS LATER:**
> BP shifts from borderline to mild
> Non-specific headaches, dizziness
> Intolerance of recumbent positions
> Central nervous system complications include vertigo, dizziness, headaches, along with deterioration of vision and mental functions
> Renal complications would result in elevated urinary protein and/or a decreased specific gravity

**YEARS LATER:**
> BP shifts into moderate range
> Symptoms include the above but are largely ignored by the patient
>
> If examined, findings would include an abnormal ECG, chest X-ray, urinalysis, possible blood work (cholesterol in particular), retinal artery modifications. If heart disease has developed, findings would include chest pain, shortness of breath, and intolerance of recumbent positions.

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**YEARS LATER:**
Malignant hypertension has set in. Symptoms include headaches bad enough to cause vomiting, loss of vision, weight loss, and confused, erratic behavior. The patient now has suffered potential life-threatening injury to the heart, kidneys, brain, and major system arteries.

**YEARS LATER:**
6 to 12 months from onset of malignant hypertension:
80% enter hypertensive crisis, also called hypertensive emergency
Death in hours

**YEARS LATER:**
12 to 24 months from onset of malignant hypertension:
100% enter hypertensive crisis and die

### 3.5.3 Mild Case

**DAY 1:**
**Patient Behavior:**
35 year-old white male enters the health care system for annual physical

**Symptoms:**
Occasionally develops persistent headache

**Diagnostics/Diagnosis:**
Standard physical
Blood pressure is found to be mildly elevated

**Treatments:**


**DAY 15:**
**Patient Behavior:**
Patient returns for evaluation of BP

**Symptoms:**

**Diagnostics/Diagnosis:**
Blood pressure still elevated

**Treatments:**

**DAY 29:**
**Patient Behavior:**
Patient returns for evaluation of BP

**Symptoms:**

**Diagnostics/Diagnosis:**
BP is elevated

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**Treatments:**
>Weight loss counseling
>Stress management counseling
>Nutrition counseling
>Smoking cessation

**DAY 36:**
**Patient Behavior:**
>Admitted to hospital for outpatient lab work-up

**Symptoms:**
**Diagnostics/Diagnosis:**
>Urinalysis
>Serum creatinine
>Serum potassium
>Uric acid
>Blood sugar
>Lipid profile
>CBC
>EKG
>CXR
>ECHO (optional)

**Treatments:**
>IV
>Oxygen (optional)
>Weight loss counseling
>Stress management counseling
>Nutrition counseling
>Specialist evaluates patient condition

**DAY 37-38:**
**Patient Behavior:**
>Admitted to hospital

**Symptoms:**

**Diagnostics/Diagnosis:**
>Upper GI series
>Renal arteriogram
>Renal biopsy
>Intravenous pyelogram
>Oxygen saturation
>Essential hypertension

**Treatments:**
>Weight loss counseling
>Stress management counseling
>Nutrition counseling
>Stage 2 drugs
>Follow-up in 1 week

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**DAY 45, 52, 59, 66, 96, 156, 246, 426:**
**Patient Behavior:**
  Follow-up visit

**Symptoms:**

**Diagnostics/Diagnosis:**
  Check BP

**Treatments:**
  Follow-up in one week

**DAY 3690-3692:**
**Patient Behavior:**
  Morbid event; hypertensive crisis

**Symptoms:**

**Diagnostics/Diagnosis:**
  Urinalysis
  Serum creatinine
  Serum potassium
  Uric acid
  Blood sugar
  Lipid profile
  CBC
  EKG
  X-ray
  Oxygen saturation
  Upper GI series
  Renal arteriogram
  Renal biopsy
  Intravenous pyelogram

**Treatments:**
  Admitted to CCU
  Monitored while his blood pressure is slowly reduced and brought under control using a
  combination of drugs
  IV
  Oxygen
  Pulseoximeter
  Weight loss counseling
  Stress management counseling
  Nutrition counseling
  Specialist evaluates patient condition
  Discharged on day 3692

**DAY 3699, 3706, 3713, 3720, 3750, 3810, 3900:**
**Patient Behavior:**
  Patient returns for follow-up

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**Symptoms:**

**Diagnostics/Diagnosis:**

**Treatments:**
Check BP

**AGE 55:**
**Patient Behavior:**
Patient enters health care system for emergency care

**Diagnostics/Diagnosis:**
Hypertensive crisis

**Treatment:**
Stage 4 drugs
Treatment protocol identical to days 3690 - 3900 with 1 additional day in the CCU

**AGE 65:**
**Patient Behavior:**
Patient enters health care system for emergency care

**Diagnostics/Diagnosis:**
Hypertensive crisis

**Treatment:**
Stage 5 drugs
Treatment protocol identical to that received at age 55 with 1 additional day in the CCU

**AGE 70:**
**Patient Behavior:**
Patient enters health care system for emergency care
Dies in ambulance in route to hospital

**Diagnostics/Diagnosis:**
Myocardial infarction

## 3.6  Influenza

### 3.6.1  Section Overview

PREVENTION:
Only 20 percent of targeted population get vaccinated. The flu shot should be administered 6 weeks before onset of flu season, from September on. Assume efficacy of vaccine is 75 percent (i.e., it fully protects the patient with no signs of infection), the balance of patients suffering only mild symptoms, if any, and a more rapid recovery period.

PREVALENCE/INCIDENCE:
Assume everyone gets it or a vaccine.  Yearly deaths from conditions stemming from the flu average 30,000 plus or minus 10,000 with the vast majority of these being elderly people (> age 65) or

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people with chronic health problems, such as heart, lung, or kidney disease.

TREATMENT:

Early Intervention: Anti-viral agent, AMANTADINE, should be given twice daily, before and during exposure (days 0-4), to be effective. If this is done, the effects would be comparable in efficacy to prior vaccination. Otherwise, treatment is palliative, directed at the symptoms, with anti-histamines, decongestants, anti-fever, and cough suppressants rounding out the list of common over-the-counter medications used. Bed rest is indicated, especially for the elderly or chronically ill, as is fluid regulation.

### 3.6.2 Mild Case

**DAY 1 - 3:**
**Patient Behavior:**
> Incubation period after exposure varies from 1 to 3 days
> Patient <35 years of age

**Symptoms:**
> Symptomless

**DAY 4:**
**Patient Behavior:**
> Patient enters health care system

**Symptoms:**
> Mild non-productive cough, headache, and chills
> Generalized body aches and a high fever (102-104°F) runny nose, sneezing, sore throat
> Tightness in the chest
> Weakness and malaise

**Diagnostics/Diagnosis:**
> Standard physical
> Patient diagnosed with influenza

**Treatments:**
> Amantadine
> Palliative

**DAY 5 - 7:**
**Patient Behavior:**
> Home recovery

**Symptoms:**
> Mild non-productive cough, headache, and chills
> Generalized body aches and a high fever (102-104°F) runny nose, sneezing, sore throat
> Tightness in the chest
> Weakness and malaise

**Diagnostics/Diagnosis:**

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**Treatments:**
    Palliative

**DAY 8 - 14:**
**Patient Behavior:**
    Work recovery

**Symptoms:**
    Generalized weakness and malaise

**Diagnostics/Diagnosis:**

**Treatments:**
    Palliative

**DAY 14:**
    Full recovery - Exit system

### 3.6.3 Moderate Case

**DAY 1 - 3:**
**Patient Behavior:**
    Incubation period after exposure varies from 1 to 3 days
    Patient 35 to 65 years of age

**Symptoms:**
    Symptomless

**DAY 4 - 7:**
**Patient Behavior:**
    Home treatment

**Symptoms:**
    Mild non-productive cough, headache, and chills
    Generalized body aches and a high fever (102-104°F) runny nose, sneezing, sore throat
    Tightness in the chest
    Weakness and malaise

**Diagnostics/Diagnosis:**

**Treatments:**
    Palliative

**DAY 8:**
**Patient Behavior:**
    Patient enters health care system

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**Symptoms:**
    Mild non-productive cough, headache, and chills
    Generalized body aches and a high fever (102-104°F) runny nose, sneezing, sore throat
    Tightness in the chest
    Weakness and malaise

**Diagnostics/Diagnosis:**
    Standard physical
    Patient diagnosed with influenza

**Treatments:**
    Palliative

**DAY 9 - 14:**
**Patient Behavior:**
    Home Recovery

**Symptoms:**
    Mild non-productive cough,  headache and chills
    Generalized body aches and a high fever (102-104°F) runny nose, sneezing, sore throat
    Tightness in the chest
    Weakness and malaise

**Diagnostics/Diagnosis:**

**Treatments:**
    Palliative

**DAY 15 - 21:**
**Patient Behavior:**
    Work recovery

**Symptoms:**
    Generalized weakness and malaise

**Diagnostics/Diagnosis:**

**Treatments:**
    Palliative

**DAY 21:**
    Full recovery - exit system

### 3.6.4  Severe Case

**DAY 1 - 3:**
**Patient Behavior:**
    Incubation period after exposure varies from 1 to 3 days
    Patient >65 years of age

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**Symptoms:**
Symptomless

**DAY 4 - 10:**
**Patient Behavior:**
Home treatment

**Symptoms:**
Mild non-productive cough, headache, and chills

Generalized body aches and a high fever (102-104°F) runny nose, sneezing, sore throat
Tightness in the chest
Weakness and malaise

**Diagnostics/Diagnosis:**

**Treatments:**
Palliative

**DAY 11:**
**Patient Behavior:**
Patient enters health care system

**Symptoms:**
Generalized weakness and malaise

**Diagnostics/Diagnosis:**
Standard physical
Influenza

**Treatments:**
Palliative

**DAY 12 - 31:**
**Patient Behavior:**
Home recovery

**Symptoms:**
Generalized weakness and malaise

**Diagnostics/Diagnosis:**

**Treatments:**
Palliative

**DAY 31:**
Full recovery - exit system

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# Section 4:  Medical Components

## 4.1  Section Overview

Submodels representative of the medical facilities within the health care system have been developed.  A Clinic, Physician Office, Hospital, Regional Medical Center, and Diagnostic Treatment Center are the medical component building blocks of the Phase I Mmdel.  Additionally, a Home submodel and a System Routing submodel have been developed as part of the health care system model.

Before entering the model, each patient is assigned a condition and a level of severity, or case study, as described in Section 3.  Services, diagnostics, and treatments required for each condition are defined by the respective case studies.

## 4.2  Medical Component Submodels and Assumptions

### 4.2.1  Medical Submodels Architecture

Each medical component submodel contains elements common to all facilities including  admission to the facility, administrative services, diagnostics, treatments provided by the facility, and exit from the facility.  A patient entering a medical facility will first be admitted and triaged by the facility staff.  A determination is made at this point whether or not the patient will remain in this facility for diagnosis and treatment.  The decision is based on the level of care available in the facility.  If all services, diagnostics, and treatments required for the patient's condition are available in the current facility,  the patient will receive all medical care required by his condition at this facility.  Otherwise, the patient is routed to a medical facility where he can receive all medical care that his condition requires.  The Phase I model does not take into account the fact that diagnostics are duplicated when a patient transfers to another facility, as this practice may or may not occur from region to region and facility to facility.

**Admission Node**

Admission to the facility accounts for time spent by the patient and administrative staff before health care is provided.  The patient's responsibility is to provide medical history while the administrative staff validates insurance coverage, acquires any existing patient records, etc.  In an emergency, the patient will receive medical attention while the medical record is retrieved.

**Consultation/Diagnostics Node**

The diagnostics node depicts the time and cost to perform any needed diagnostics for a patient's medical condition.  A physician is required for diagnosis and therefore this node is sometimes referred to as the consultation node.  If the facility is staffed with a physician, the consultation is completed on site.  In the future health care system model, the consultation can be achieved through a remote link.  The total cost of diagnostics executed for each patient based on medical condition and level of severity is calculated in this node.

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**Services Node**

The services node represents any services that are provided in a medical facility for the medical conditions modeled. Services provided in each facility are described in Section 2.5. A calculation of cost of services provided for each patient based on medical condition and level of severity is gathered in this node.

**Exit Node**

Exit from the facility includes discharge home, transfer to another facility, or referral to another facility.

### 4.2.2 Clinic Submodel

In Phase I, the clinic submodel is parameterized, offering conjectural administrative services, diagnostics, and treatments. Multiple "what if" scenarios can be created and input into the model to examine the effects of the Unit Cell Concept on health care delivery.

### 4.2.3 Physician Office Submodel

In Phase I, the Physician Office submodel is parameterized as a primary care facility, offering established administrative services, diagnostics, and treatments. This facility is an existing component of today's health care system. In the future system, this facility is represented as having remote communication links to all other facilities. Refer to Appendix A for a complete listing of the parameter values for this component.

### 4.2.4 Hospital Submodel

The Hospital submodel is parameterized as a community hospital, offering all administrative services, diagnostics, and treatments required for the five medical conditions modeled. Additionally, this facility offers emergency care. This facility is an existing component of today's health care system. In the future system, this facility is represented as having remote communication links to all other facilities. Refer to Appendix A for a complete listing of the parameter values for this component.

### 4.2.5 Regional Medical Center Submodel

The Regional Medical Center submodel is the home for world experts in specialized fields of medicine and advanced, state-of-the-art medical equipment. The five conditions modeled in Phase I did not require treatment beyond the comprehensive services offered in the community hospital.

### 4.2.6 Diagnostic Treatment Center Submodel

The Diagnostic Treatment Center submodel was developed as part of Phase I but was not used for the diagnosis or treatment of the five medical conditions modeled.

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## 4.3 Home Submodel

Three components make up the home submodel including Home Treatment, Home Recovery, and Work Recovery.

**Home Treatment**

Home treatment is characterized by the time a patient spends at home self-treating the symptoms of a condition before entering the health care system. The presentation delay is incurred here. If self-treatment is unsuccessful, the patient may choose to enter the health care system for diagnostics and treatments.

**Home Recovery**

After discharge from the medical facilities, the patient enters the home recovery node. The home recovery component reflects the time the patient will spend at home in recovery unable to work or attend school.

**Work Recovery**

For some conditions, such as myocardial infarction, a longer recovery may be required. The patient is able to work but still requires periodic visits to the doctor until full recovery has been achieved. This constitutes the Work Recovery node. When the patient returns to normal, he will exit the system.

## 4.4 System Routing Submodel

### 4.4.1 System Routing Submodel Overview

This submodel controls patient (*transaction*) trajectory between the Home, Clinic, Physician Office, Hospital, Regional Medical Center, and Diagnostic and Treatment Center submodels. Additionally, it controls the flow between the nodes Where_Next, Morgue, and Collect_Statistics. Upon initial entry into System_Routing, all patients will be routed to the Home submodel (*for additional Home submodel details, see section 6.3*). When a patient leaves the Home submodel for the first time, an initial destination is obtained from a set of condition and health care rules. All subsequent routing within the system routing submodel will be calculated each time a patient requires moving between facility submodels or nodes. The following is a brief description of node characteristics.

**Enter Node**

Point at which a patient enters the submodel. From this point, a patient will always proceed to the home submodel.

**Where_Next Node**

The Where_Next Node within the System Routing Submodel serves as the mechanism by which patients are routed from one health care facility to another. Initially, when a patient leaves Home in

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an attempt to receive health care, the Where_Next Node will route the patient to the appropriate facility as an initial destination. Upon receiving the necessary tests, treatments, and services at the initial destination facility, the patient will once again be routed by the Where_Next node to another facility based upon further tests, treatments, and services that may be required. The decision as to where the patient should then be routed hinges on the specific tests, treatments, and services of each of the existing facilities that are supported in their parameterized configurations. This sequence of events will occur until the patient no longer has a need for health care facility support (at which point the Where_Next Node will route the patient back to Home) or until the patient dies.

**Morgue Node**

This node simply keeps track of the number of patients who have died from a particular condition (e.g. RSV). The presence of this node is primarily for display purposes only because the statistical collection occurring within this node could be incorporated into the Collect_Statistics Node.

**Collect_Statistics Node**

All patient summary information that consists of total cost generated by the patient and total time spent in the system (*simulation*) on a condition-specific basis is collected for statistical analysis.

**Exit Node**

Point at which a patient exits the submodel and simulation.

## 4.5  Model Configuration

The current health care system components represented in the model configuration include the General Practitioner, or Primary Physician Office, Community Hospital, or Centers of Excellence, Regional Medical Center, technology resources, and system routing.

The Unit Cell Concept is illustrated in figure 4.5.1. This configuration builds on the current health care system components, adding elements unique to the Unit Cell Concept. Solid lines represent technological and operational lines of communication (TLC) that are proposed to exist between medical entities.

Figure 4.5.1  Operational Unit Cell (**See attached figure of Operational Unit Cell**)

## 4.6  Future Plans

Once the Unit Cell is implemented and an ordered infrastructure is in place, then a host of technologies can be considered for deployment. To accommodate the requirements of future versions, reusable submodels will be incorporated into the Unit Cell model. Known components include high-temperature superconducting magnetic resonance imaging (HTSC-MRI), advanced X-ray imaging, mass storage, high performance computing, high bandwidth local area networking, and other types of low-cost, portable diagnostic equipment currently and futuristically under development.

# An Operational Unit Cell



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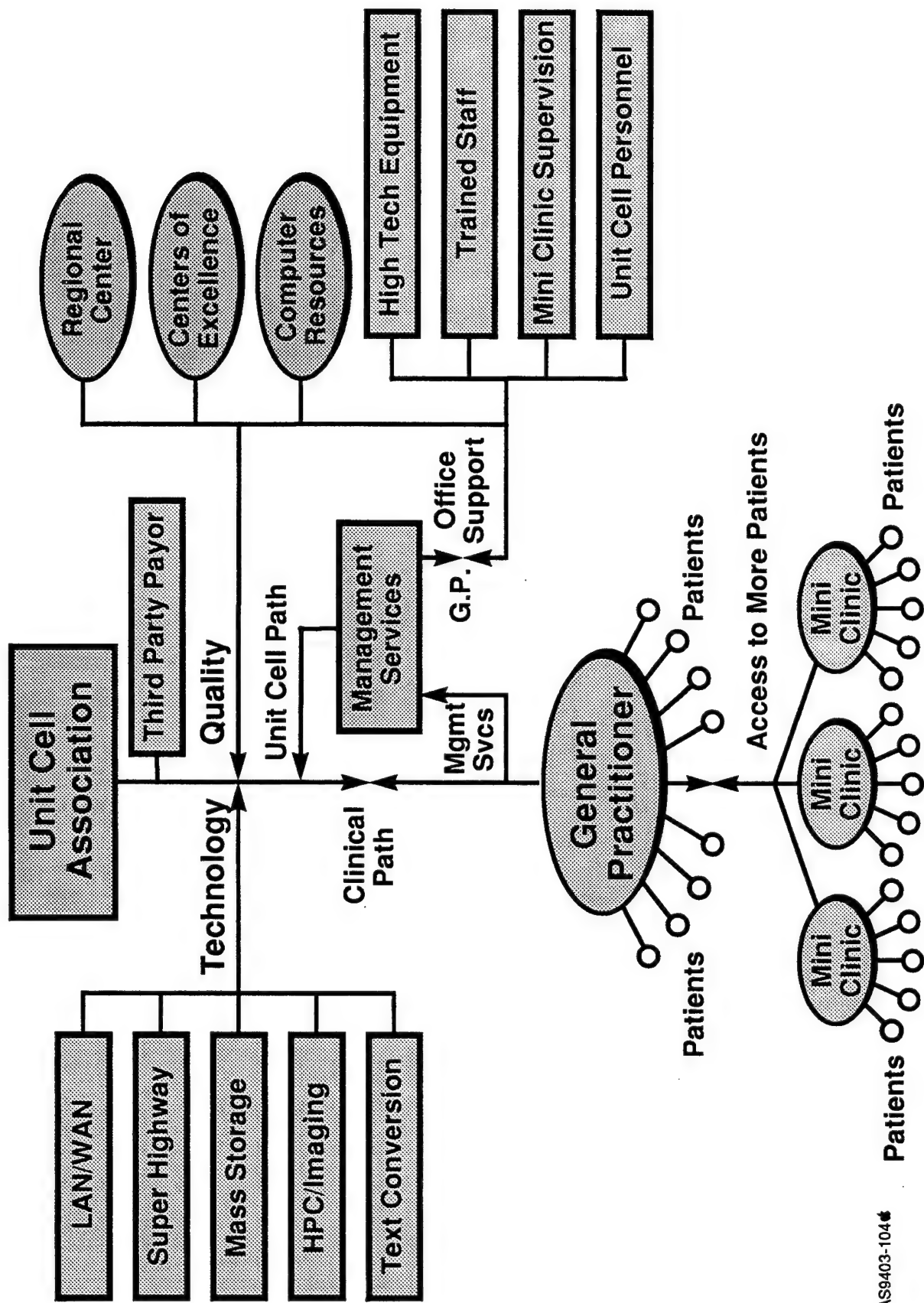
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# Section 5:  Model Inputs

## 5.1  Section Overview

System configuration, system loading, and system tasking are inputs into the Unit Cell model and can be varied over a wide range.  Configuration is accomplished via the parameter file, system loading is provided by scenarios,  and tasking is accomplished through the health care rules database defined by the case studies for each medical condition.  A description of each for the HCES model follows.

## 5.2  Parameters

### 5.2.1  Section Overview

Each facility is highly parameterized to allow for flexibility and reusability.  Parameterized components support the ability to quickly modify the administrative services, treatments, and diagnostics available at each medical facility.  This allows for increased flexibility in experimentation.  Following is an example that illustrates the advantage of this capability by comparing two independent runs of the same model diversely parameterized.

A patient enters the health care system with a sprained ankle.  The first model run parameterizes the facility with a medical attendant, remote consultation capability with a physician and radiologist, and limited diagnostic equipment.  The physician suspects a broken ankle and requests an X-ray before making a diagnosis.  Because the facility is not equipped with an X-ray machine, the patient is sent to the hospital where an X-ray is performed and the diagnosis of a broken ankle is made. The patient is treated in the hospital and sent home.

The second model run parameterizes the initial facility with additional equipment including an X-ray machine.  This new capability coupled with the remote link to the physician and radiologist allows the diagnosis of the suspected broken ankle at the initial facility. The patient is treated, put in a cast, and sent home.  In just a few minutes, parameter values can be changed and new model run made enabling the analyst to evaluate the effects of the change in patient trajectory with the addition of the X-ray machine at the initial facility.  It is important to emphasize that this can be done without making any software modifications.

Through parameterization, the model components are customized for the specific architecture requirements.  The parameters common to all medical component submodels are described in the following sections.

### 5.2.2  Medical Component Parameters

#### 5.2.2.1  General Parameters

Name of Medical Facility -- Each instance of a facility is identified by a facility name and unique identifier.

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New Admit Delay -- Time required for admission process of a new patient.

Repeat Admit Delay -- Time required for admission process of a repeat patient.

Simple Discharge Delay -- Time required for a simple discharge.

Moderate Discharge Delay -- Time required for a moderate discharge.

Complex Discharge Delay -- Time required for a complex discharge.

Co-Payment -- Patient charge for health care in a facility.

Administrative Services Bit Map -- Sets the services available in the medical facility of all possible services modeled.

Tests Bit Map -- Sets the tests available in the medical facility of all possible tests modeled.

Treatments Bit Map -- Sets the tests available in the medical facility of all possible tests modeled.

Log File Name -- File name to output logging data.

Log Trace Options -- Sets the logging data options.

Log Delay Until Start -- Interval start time of logging data.

Log End Time -- Interval stop time of logging data.

### 5.2.2.2 Administrative Service Parameters

Primary Care Consult Cost
Remote Primary Care Consult Cost  (available future only)
Remote Specialist Consult Cost      (available future only)
Specialist Hospital Visit Cost
Floor Room and Board Cost
Cardiac Care Unit Room and Board Cost
Intensive Care Unit Room and Board Cost
Emergency Care Cost

### 5.2.2.3 Diagnostics Parameters

ABG Delay
ABG Cost
Blood Sugar Delay
Blood Sugar Cost
Cardiac Enzyme Delay
Cardiac Enzyme Cost
Cardio-Respiratory Monitor Cost
CAT Scan Delay
CAT Scan Cost

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CBC Delay
CBC Cost
Echocardiogram Delay
Echocardiogram Cost
EKG Delay
EKG Cost
HGB HCT Delay
HGB HCT Cost
Lipid Profile Delay
Lipid Profile Cost
Liver Function Delay
Liver Function Cost
MRI Delay
MRI Cost
O2 Saturation Delay
O2 Saturation Cost
RSV Culture Delay
RSV Culture Cost
Standard Physical Delay
Standard Physical Cost
SMAC 12 Delay
SMAC 12 Cost
SMAC 18 Delay
SMAC 18 Cost
Sputum Specimen Delay
Sputum Specimen Cost
Stress Test Delay
Stress Test Cost
Serum Creatinine Delay
Serum Creatinine Cost
Serum K Delay
Serum K Cost
Uric Acid Delay
Uric Acid Cost
Urinalysis Delay
Urinalysis Cost
X-Ray Delay
X-Ray Cost

### 5.2.2.4 Treatments Parameters

Antibiotic Delay
Antibiotic Cost
Antiviral Delay
Antiviral Cost
IV Delay
IV Cost
O2 Saturation Delay
O2 Saturation Cost
Rehydration Delay
Rehydration Cost

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Respiratory Therapy Delay
Respiratory Therapy Cost
Ventilation Delay
Ventilation Cost
Nutrition Counseling Delay
Nutrition Counseling Cost
Smoking Counseling Delay
Smoking Counseling Cost
Stress Management Delay
Stress Management Cost
Weight Loss Counseling Delay
Weight Loss Counseling Cost

### 5.2.3 Submodel Parameter Values

Parameter values are echoed in the HCES Model Report. Please refer to Appendix A for a complete listing of the parameter values for each submodel.

## 5.3 Scenarios

### 5.3.1 Loading the Model

Scenarios characterize system loading, the actual work that the system is tasked to perform. Patient scenarios are the key element in loading the HCES Model, setting the stage for model execution. In the context of the HCES Model, a scenario can be thought of as the patient load associated with a specific Unit Cell being examined over a defined period of time.

This patient load is described on the basis of characteristics provided by the user in a customized scenario specification file. As each patient is created, the condition associated with the patient and the relative time at which the patient enters the model are generated as well. In addition, attributes associated with physical characteristics and demographics of the patient can also be created. Because any or all of these patient attributes may play a part in the trajectory of the patient through the model, the flexibility exists to include whatever might be necessary within the domain of any specific Unit Cell. The mechanics of how to create these types of scenarios as well as the spectrum of scenario generation capabilities that exist are included in Section 8.

### 5.3.3 Phase I Scenarios

Phase I delivers the benefits of the Unit Cell based upon a synthetic population statistically weighted to present five common medical conditions. This region consists of three districts, District 1, District 4, and District 7. Each ward is differentiated by economic and social demographics resulting in varying incidences of medical conditions. In Phase I, depicting the details of the wards was given low priority; thus, only minor differences in demographics are realized. The demographics encompassed in the Phase I effort are limited to population breakdown by age, patient income, and physician accessibility.

Three scenarios representative of District 1, District 4, and District 7 provide the patient loading for the Phase I model. Each scenario represents the condition incidences for the five medical condi-

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tions based on the demographics of this region. In this region, low income and inadequate physician accessibility are the predominant reasons patients do not seek health care at the earliest sign of symptoms. Refer to Appendix A for a graphical representation of the scenarios.

## 5.4 Health Care Rules Database

### 5.4.1 Database Design Overview

The "*Health Care Rules Database*" used by the model is not a true database. It is simply a set of several internal data structures that are used to store information on specific medical conditions. These data structures are initialized and populated with all the necessary information at model run-time. Unfortunately, at the current time, all this information is "*hard coded*" into the model and requires recompiling if any changes are made to the condition rules. An investigation is underway-into a commercial database package that will handle the plethora of case studies for future versions of the model.

### 5.4.2 Data Structures Overview

Each condition is represented by two sets of data structures: a presentation pool and a health care pool. For each medical condition case study, the presentation pool is populated with a points threshold, or probability that the patient enters the health care system based on the sum of his attributes, hours of presentation delay, initial medical facility destination in the current system, initial medical facility destination in the health care system, hours in home recovery, type of condition, and an index into the health care pool where this case study's health care rules begin. As for the health care pool, for each medical condition case study, the structure is populated with a sequential series of discrete events (*database records*) specifying all medical-related requirements at a specific time. The composition of each record consists of the time at which the event takes place in relation to patient creation, type of medical tests, medical treatments, and administrative services required at that time, whether the patient lives or dies, and a pointer back to this case study's entry in the presentation pool.

### 5.4.3 Database Queries

Four database queries are available to the model as follows:

- Query for the amount of time that must pass until a patient presents in the health care system, obtaining the initial medical facility destination where the patient will present.

- Query for the set of medical tests, medical treatments, and administrative requirements of the patient.

- Query for the amount of time required for a patient to recover from his condition.

- Query for the amount of delay needed before the next patient event takes place.

These four database queries are essential in determining patient trajectory at all levels within the model.

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## 5.5 Tasking

### 5.5.1 Patient Trajectory

Tasking topology, controlled by the System Routing submodel, routes the patient through the health care system facilities based on medical condition and case study. Because a case study approach has been procured, the administrative services, diagnostics, and treatments required by a patient presenting with a medical condition are known before model execution. The trajectory, or treatment path, of the patient is determined dynamically during model execution.

A patient entering the health care system has an allocated medical condition and level of severity unknown by the physician. Based on the symptoms the patient displays, the medical attendant will perform a defined set of tests so that a diagnosis can be made. Administrative services, diagnostics, and treatments performed on a patient vary not only with condition but also with the level of severity. The protocols administered for the five medical conditions identified for the Phase I effort are described in Section 3.

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# Section 6: Model Outputs

## 6.1 Section Overview

Assessing the efficiency of the Unit Cell is the overall objective of the model. Key measures of effectiveness have been identified and collected and output in several formats. The custom model report provides an overview of system behavior and paves the way for analysis of the model. Graphical output is also produced that enhances the analysis process.

## 6.2 Custom Model Report

### 6.2.1 Statistics Overview

Two types of statistics are collected in the HCES Model: time variable statistics and cost variable statistics. The time variable statistics assess the time spent in the health care system as well as a breakdown of time spent by the patient in the medical facilities. Time variable statistics are collected but are not meaningful in the Phase I effort, with the exception of the Overall Time in System statistic discussed below. Resource utilization takes into account scheduling delays, medical staff availability, etc. This addition to the model leads to tracking the effects of the Unit Cell Concept on restricted resources in greater detail.

Cost variable statistics measure the cost of health care in terms of medical and economic cost and relative human suffering of a condition to other conditions. Cost is calculated as the patient flows through the health care system. Impacts of scheduling delays and resource availability are not accounted for in Phase I. Fixed costs for all tests, treatments, and services include the medical staff's time as well as the cost of the services, diagnostics, and treatments. The parameter values vary between medical components. For example, it is possible to parameterize the model such that a physical examination performed in a clinic has a lower cost than the same procedure performed in a hospital.

A total patient count by condition and severity is also reported. This count is a reflection of the scenario, an input into the model.

Following is a list of statistics collected with a description of each. As a reminder, only cost variable statistics are meaningful in Phase I, the key measure of effectiveness for this level of effort.

### 6.2.2 System Level Statistics

**Time in System by Patient Condition**
**Overall Time in System All Conditions**

Measurement from the time the patient enters the health care system until the patient exits the health care system. This statistic is meaningful in Phase I because we are using a Case Study approach. The Case Study defines the duration of time the patient will be in the health care system and the tests, treatments, and services required for the condition. Collection of this statistic provides the basis for the calculation of economic costs, as

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described in Section 2.2, for each condition.

### Per Patient Cost in Health Care System by Condition

Average cost per patient for each the medical condition. Includes the cost of diagnostics, treatments and services provided in all medical facilities.

### Total Cost in Health Care System by Condition

Measurement of the cumulative cost for each medical condition for all patients in the system with the given condition. Includes the cost of diagnostics, treatments, and services provided in all medical facilities.

### Total Health Care Cost for All Conditions

Measurement of the total cost for all health care services provided for all conditions modeled. Includes the cost of diagnostics, treatments, and services provided in all medical facilities.

### Total Number of Patients by Condition

Tally of the number of patients entering the health care system with one of the five conditions modeled in Phase I.

### Total Number of Mild Cases by Condition

Incidence cases per condition entering the health care system with a mild presentation.

### Total Number of Moderate Cases by Condition

Incidence cases per condition entering the health care system with a moderate presentation.

### Total Number of Severe Cases by Condition

Incidence cases per condition entering the health care system with a severe presentation.

### Total Number of Deaths by Condition

Tally of the number of deaths associated with each condition modeled.

## 6.2.3  Home Submodel Statistics

### Home Treatment Time

Time patient spends at home self-treating before entering the health care system.

### Recovery Admissions Rate

Frequency of patients entering the home submodel for recovery.

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**Recovery Daily Census**

> Average, minimum, and maximum number of patients in Home Recovery on any given day.

**Home Recovery Time**

> Time for patient recovery before returning to work or exiting system.

### 6.2.4 Medical Facility Submodel Statistics

The following statistics are collected for each medical facility submodel, including the Clinic, Physician Office, Hospital, Regional Medical Center, and Diagnostic Treatment Center.

**Daily Census**
> Average, minimum, and maximum number of patients in the medical facility at any given time.

**Administrative Protocol**
> Time required for administrative duties.

**Admissions Rate**
> Frequency of arrival of patients to medical facility.

**Triage**
> Time required for medical attendant to perform triage.

**Consultation/ Diagnostics**
> Time required for diagnostics. Also includes time for physician to make diagnosis and recommend treatment.

**Medical Facility Treatments**
> Time required for treatment of medical condition.

**Medical Facility Services**
> Time required for administrative or provided patient services.
> (i.e., floor room and board)

**Medical Facility Response Time**
> Time calculated from time of entry into medical facility to time of exit from medical facility.

**Per Patient Cost in Medical Facility by Condition**
> Average cost per patient for each medical condition is collected and reported in each of the medical facility submodels. Includes the cost of tests, treatments, and services provided in the medical facility.

**Total Cost in Medical Facility by Condition**
> Measurement of the cumulative cost of health care by condition in each medical facility

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for all patients seeking medical attention. Includes the cost of diagnostics, treatments, and services provided in the medical facility.

**Total Cost in Medical Facility for All Conditions**
Measurement of the total cost for all health care services provided in each of the medical facility submodels for all conditions modeled. Includes the cost of diagnostics, treatments and services provided in the medical facility.

A sample output report is included in Appendix A.

## 6.3 Graphical Output

Graphs are used to gain insight into system behavior over time. Presentation of results data in graphical format allows decisionmakers to assimilate information from large data files quickly and accurately. The simulation group has standardized output to optimize use of the graphing software and the point-and-click user interface that provides many graphing options embedded in the System Simulation Environment@. Users can easily select the most meaningful format for viewing specific types of data.

Graphical results of the Unit Cell model are included in Appendix A.

## 6.4 Current Versus Unit Cell Health Care System Model Analysis

### 6.4.1 Assumptions

- Patient awareness can be increased in both the current and future health care systems.

- Implementation of the Unit Cell Concept in the health care system facilitates an increase in patient accessibility.

- An increase in patient accessibility in the current health care system is not modeled.

- The Unit Cell Concept provides comparable services at a lower cost than the Physician Office in the current health care system.

- The cost of diagnostics and treatments remains constant in the Physician Office, Hospital, and Regional Medical Center in current and future architectures.

- As patient awareness and accessibility increase, presentation delay decreases.

- Costs measured in the model are medical costs only and do not take into account economic or human suffering costs. However, *economic cost* savings are potentially a significant contributor when calculating overall cost savings.

- A patient will access health care at the closest health care provider.

- Measures of effectiveness are based on cost, average state of health, person days of ill-

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ness, and accessibility.

- Physicians consistently take appropriate diagnostic actions.

### 6.4.2 Overall Conclusions

- **Unit Cell Concept**
    - Increases the number of people treated.
    - Improves probability of treatment.
    - Improves treatment rate.
    - Improves health of the population.
    - Results in a corresponding decrease in mortality.

- **Increase in Unit Cell efficiency results in:**
    - Lower cost per treated patient.
    - Reduced cost to insured patients.
    - Increase in proportion of uninsured patients getting access to health care.

### 6.4.3 Patient Trajectory Conclusions

#### 6.4.3.1 Pneumococcal Pneumonia

The total incidence of pneumococcal will remain constant between all scenarios; only the severity of the condition and cost to the patient will change. It should be noted that increases in the incidence of a condition's severity are caused by shifting severe cases to moderate or mild and shifting moderate cases to mild.

**Current System vs. Future System (*no shift in patient awareness and accessibility*)**
In this scenario, the severity of pneumococcal in a given population will remain constant. However, the cost associated with this condition decreased by 3.5 percent simply because earlier and cheaper introduction into the Unit Cell health care system provides lower cost health care delivery.

**Current System vs. Future System (*25 percent shift in patient awareness and accessibility*)**
This scenario produced a decrease in severe cases by 48 percent, a decrease in moderate cases by 18 percent, and an increase in mild cases by 25 percent. With these changes in the severity of pneumococcal cases, this produced a cost savings of 39 percent over the current system.

**Current System vs. Future System (*50 percent shift in patient awareness and accessibility*)**
This scenario produced a decrease in severe cases by 100 percent, a decrease in moderate cases by 43 percent, and an increase in mild cases by 43 percent. With these changes in the severity of pneumococcal cases, this produced a cost savings of 82 percent over the current system.

**Current System vs. Future System (*75 percent shift in patient awareness and accessibility*)**
This scenario produced a decrease in severe cases by 100 percent, a decrease in moderate cases by 76 percent, and an increase in mild cases by 54 percent. With these changes in

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the severity of pneumococcal cases, this produced a cost savings of 90 percent over the current system.

Additional analysis of the future system should include the effects of a single change in the system. For example, shift a percentage of patients presenting with a severe case to mild case while leaving the number of moderate presentations constant. Repeat this, shifting only moderate presentations. Analyze the effects to determine if there is a main cost driver.

### 6.4.3.2 RSV Pneumonia

The incidence of RSV will remain constant between all scenarios, only the severity of the condition and cost to the patient will change. It should be noted that increases in the incidence of a condition's severity are caused by shifting severe cases to moderate or mild and shifting moderate cases to mild.

**Current System vs. Future System** (*no shift in patient awareness and accessibility*)
In this scenario, the severity of RSV in a given population will remain constant. However, the cost associated with this condition decreased by 2 percent simply because the Unit Cell environment provides lower-cost health care.

**Current System vs. Future System** (*25 percent shift in patient awareness and accessibility*)
This scenario produced a decrease in severe cases by 55 percent, an increase in moderate cases by 10 percent, and an increase in mild cases by 2 percent. With these changes in the severity of RSV cases, this produced a cost savings of 3 percent over the current system. Even though cost decreased only by 3 percent, overall quality of life increased dramatically. Normally, severe cases of RSV result in death; and, with a 25 percent shift in awareness and accessibility, deaths associated with RSV decreased by 55 percent.

**Current System vs. Future System** (*50 percent shift in patient awareness and accessibility*)
This scenario produced a decrease in severe cases by 100 percent, an increase in moderate cases by .5 percent, and an increase in mild cases by 5 percent. With these changes in the severity of RSV cases, this produced a cost savings of 6 percent over the current system. Even though cost decreased only by 6 percent, overall quality of life increased dramatically. Normally, severe cases of RSV result in death; and, with a 50 percent shift in awareness and accessibility, deaths associated with RSV decreased by 100 percent.

**Current System vs. Future System** (*75 percent shift in patient awareness and accessibility*)
This scenario produced a decrease in severe cases by 100 percent, a decrease in moderate cases by 47 percent, and an increase in mild cases by 7 percent. With these changes in the severity of RSV cases, this produced a cost savings of 9 percent over the current system. Even though cost decreased only by 9 percent, overall quality of life increase dramatically. Normally severe cases of RSV result in death, and with a 75 percent shift in awareness and accessibility, deaths associated with RSV decreased by 100 percent.

### 6.4.4 Myocardial Infarction

The incidence of myocardial infarction will remain constant between all scenarios; only the severity of the condition and cost to the patient will change. It should be noted that increases in the incidence of a condition's severity are caused by shifting severe cases to moderate or mild and shifting

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moderate cases to mild.

> **Current System vs. Future System (*no shift in patient awareness and accessibility*)**
> In this scenario, the severity of myocardial infarction in a given population will remain constant. However, the cost associated with this condition decreased by 3 percent.

> **Current System vs. Future System (*25 percent shift in patient awareness and accessibility*)**
> This scenario produced a decrease in severe cases by 53 percent, a decrease in moderate cases by 15 percent, and an increase in mild cases by 13 percent. With these changes in the severity of myocardial infarction cases, this produced a cost savings of 28 percent over the current system.

> **Current System vs. Future System (*50 percent shift in patient awareness and accessibility*)**
> This scenario produced a decrease in severe cases by 100 percent, a decrease in moderate cases by 28 percent, and an increase in mild cases by 45 percent. With these changes in the severity of myocardial infarction cases, this produced a cost savings of 49 percent over the current system.

> **Current System vs. Future System (*75 percent shift in patient awareness and accessibility*)**
> This scenario produced a decrease in severe cases by 100 percent, a decrease in moderate cases by 76percent, and an increase in mild cases by 60 percent. With these changes in the severity of myocardial infarction cases, this produced a cost savings of 67 percent over the current system.

### 6.4.5 Hypertension

The incidence of hypertension will remain constant between all scenarios, only the severity of the condition and cost to the patient will change. It should be noted that increases in the incidence of a condition's severity are caused by shifting severe cases to moderate or mild and shifting moderate cases to mild.

> **Current System vs. Future System (*no shift in patient awareness and accessibility*)**
> In this scenario, the severity of hypertension in a given population will remain constant. However, the cost associated with this condition decreased by 19 percent.

> **Current System vs. Future System (*25 percent shift in patient awareness and accessibility*)**
> This scenario produced a decrease in moderate cases by 23 percent, and an increase in mild cases by 3 percent. There are no cases of "*Severe Hypertension*" in this scenario. With these changes in the severity of hypertension cases, this produced a cost savings of 19 percent over the current system.

> **Current System vs. Future System (*50 percent shift in patient awareness and accessibility*.**
> This scenario produced a decrease in moderate cases by 44 percent, and an increase in mild cases by 6 percent. There are no cases of "*Severe Hypertension*" in this scenario. With these changes in the severity of hypertension cases, this produced a cost savings of 19 percent over the current system.

> **Current System vs. Future System (*75 percent shift in patient awareness and accessibility*)**
> This scenario produced a decrease in moderate cases by 76 percent, and an increase in mild cases by 10 percent. There are no cases of "*Severe Hypertension*" in this scenario. With these changes in the severity of hypertension cases, this produced a cost savings of

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19 percent over the current system.

The amount of savings to the patient remained constant regardless of the shift in patient awareness and accessibility. This is a result of having only one case study of hypertension implemented.

### 6.4.6 Influenza

The incidence of Influenza will remain constant between all scenarios; only the severity of the condition and cost to the patient will change. It should be noted that increases in the incidence of a condition's severity are caused by shifting severe cases to moderate or mild and shifting moderate cases to mild.

**Current System vs. Future System (*no shift in patient awareness and accessibility*)**
In this scenario, the severity of influenza in a given population will remain constant. However, the cost associated with this condition decreased by 35 percent.

**Current System vs. Future System (*25 percent shift in patient awareness and accessibility*)**
This scenario produced a decrease in severe cases by 49 percent, a decrease in moderate cases by 15 percent, and an increase in mild cases by 14 percent. With these changes in the severity of influenza cases, this produced a cost savings of 37 percent over the current system.

**Current System vs. Future System (*50 percent shift in patient awareness and accessibility*)**
This scenario produced a decrease in severe cases by 99 percent, a decrease in moderate cases by 32 percent, and an increase in mild cases by 25 percent. With these changes in the severity of influenza cases, this produced a cost savings of 38 percent over the current system.

**Current System vs. Future System (*75 percent shift in patient awareness and accessibility*)**
This scenario produced a decrease in severe cases by 100 percent, a decrease in moderate cases by 65 percent, and an increase in mild cases by 34 percent. With these changes in the severity of influenza cases, this produced a cost savings of 38 percent over the current system.

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# Section 7: Utilities

This section contains a discussion of the reusable tools utilized to support the HCES model.

## 7.1 Scenario Generation Capability

Recall from section 5 the discussion of scenarios as an input to the model. The following sections describe the tool used to create the patient scenarios.

### 7.1.1 Condition Incidence Scenarios

The Phase I version of the HCES Model has been implemented in such a way that the primary trajectory catalyst is the patient condition or disease. The Statistical Scenario Generator@ supports this implementation in that it creates patients who are afflicted with a specific condition. For example, it may be a historical fact that a given percentage of the HCES population is afflicted with Influenza within any given year. Further, it may be known that Influenza is a seasonal disease in which some percentage of the cases occur during the winter months. The scenario generator fully supports these types of statistical data in that it is capable of generating not only the correct number of patients with a given disease but also reflects the patterns of high and low disease incidence for the duration of a given timeframe. This can be helpful in loading the model with time patterns associated with specific conditions that mirror the real world.

### 7.1.2 Patient Attributes and Presentation Boundaries

One of the more intriguing directions evolving from the design of the Phase I version of the HCES Model is the introduction of patient presentation boundaries. Certainly within any HCES region will exist a number of factors that contribute to overall patient behavior in response to known illness or preventive medicine. Examples might include physician accessibility, average distance to nearest physician, and income. The scenario generator allows for the statistical inclusion of these types of factors to be associated with patient populations. Ultimately within the HCES Model domain, these types of patient attributes influence both the delay prior to initial entry into the health care system as well as possible adherence to follow-up healing activities. Although quantifying these types of factors may be difficult and will obviously require much regional population study, the scenario generator offers the flexibility to introduce these types of boundaries into the HCES Model.

### 7.1.3 Scenario Generator Capabilities Highlights

The scenario generator utility allows the user to customize a scenario on the basis of known environmental and/or patient attributes. This customization process includes the ability to control frequency of patients, quantity of patients, and patient attributes and boundaries as described in the previous section. Several scenario generator capabilities exist that allow the user to have this type of control. Scenario specification files allow the user to stipulate customization requests in terms of constants, probability distributions, and custom distributions. For example, an essential issue within a specific HCES region may be the existence of a constant ratio of the population per physi-

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cian. Equally important may be the fact that the physician proximity is an average of 5 miles normally distributed with a standard deviation of 1 mile. Likewise, it might be imperative to work into the scenario the fact that 30 percent of the population is covered by Medicare/Medicaid, 60 percent of the population is covered by HMO/PPO, and the remainder of the population is uninsured. Each of these potential regional issues can be used as factors in the generation of a HCES scenario and can be easily specified in the scenario specification file.

### 7.1.4 Reference

An in-depth discussion of scenario generator syntax and semantics exists in the document "generic_scenario_generator.doc" that can be found in the OAM submodels control directory. Descriptions of each individual statistical distribution (both mainstream and custom), examples and exercises can be located within the context of this document. This reference material is not included with the Phase I document.

## 7.2 Raw Scenario to Graphable Scenario

### 7.2.1 Condition Incidence Histogram

A utility exists to produce a snap-like file from a raw scenario file suitable for printing by the System Simulation Environment (SSE) from the scenario files. This is useful because it allows the user to look at the scenarios graphically.

### 7.2.2 Condition Attributes Log

A utility exists to produce a log-like file from a raw scenario file suitable for printing by the SSE such that attributes of a patient presenting with a medical condition can be graphed. Currently, these attributes include income, proximity to nearest health care services, and population per physician. These attributes are produced by the scenario generator for each patient presenting with a medical condition at a medical facility.

## 7.3 Event Log

An event log is captured for each submodel. Each event log prints the time of occurrence, condition identifier, cumulative cost of health care provided to current patient, and cumulative cost of health care provided in the medical facility. The collected data for an event or submodel can be modified independently of other events to better satisfy the needs of the HCES Model analysis.

The event log for each of the medical facility submodels consists of the following:

> Admit patient to facility
> Diagnostic tests required by patient condition
> Consulting services required by patient condition for diagnosis and/or treatment
> Treatment provided to patient

The event log is useful for tracking patient trajectory and for debugging purposes.

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## 7.4 SSE Graphing Utility

The SSE provides a robust modeling and analysis tool to support studies, proposals, and programs. This tool is used to support analysis of the HCES model.

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# Section 8: Test Plan

## 8.1 Section Overview

Verification of the HCES Model, a Phase II task, will certainly be critical to the quality of the finished product and requires a Test Bed site as an external standard of measure. The simulation team has been moving toward the creation of a test plan that will contain specific test cases to ensure that the model is executing successfully. The test plan will be a dynamic reference point for model verification in that it will be appropriately updated as additional test cases are devised for new conditions and as new services are required for existing conditions. Also, the test plan will be made more robust as additional model capability is added. The test cases applicable for the Phase I model follow.

## 8.2 Test Cases

| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Home Submodel | Establish a scenario where there exists one patient with a transient condition within the scenario file. Ensure that the patients "first stop" is the home submodel and that his "last stop" is also the home submodel. This can be verified either by tracing the patient via SES animation or via the debugger. | Model Topology |
| Home Submodel | Establish a scenario where there exists one patient with a chronic condition within the scenario file. Ensure that the patients "first stop" is the home submodel and that the number of ensuing stops at home matches the number specified in the health care rules (dbase.sim file). This can be done by setting a break at "home entrance". | Model Topology |
| Home Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set up a breakpoint in the "home treatment" node. Verify that the delay at this node is defined in the attribute unshared structure and that the treatment cost is accurately calculated for each patient. | Model Parameters |

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| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Home Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set up a breakpoint in the "home recovery" node. Verify that the delay at this node is as defined in the attribute unshared structure and that the recovery cost is accurately calculated for each patient. | Model Parameters |
| Home Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each chronic condition. Set up a breakpoint in the "work recovery" node. Verify that the delay to the next event is in accordance with the condition defined in the database. | Database Query |
| Home Submodel | Establish a scenario where there exists one patient per condition in the model. Verify that the appropriate statistical sample collection is done at the culmination of home submodel processing. This can be done by setting a breakpoint at the "collect statistics" custom node and tracing the execution by condition. | Model Statistics |
| Clinic Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set up a breakpoint in the "enter clinic" node. Verify that each patient arriving at this node should do so by comparison with health care rules as defined in dbase.sim. Ensure the accounting of all patients arrive at this node. | Database Query |
| Clinic Submodel | Verify that the actual delays for clinic admission and clinic triage accurately reflect the delay times requested in the clinic submodel portion of the parameter .hmi file. | Model Parameters |
| Clinic Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set a breakpoint in the "services required" node within the clinic submodel domain. By using the debugger, ensure that each service, treatment, and consultation required is accommodated for each patient who enters the clinic. As each "where next" loop is traversed, ensure that the unshared variable associated with the action performed is reset to 0. | Model Trajectory |

**E-SYSTEMS**

| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Clinic Submodel | Keep the previously built scenario. Set a break-point in the "clinic consult" node. Ensure that the administrative costs are accurately calculated based upon the administrative services needed for the patient and the costs reflected in the parameter .hmi file. Also, ensure that the total administrative cost takes into account the clinic visit cost which is also a parameter in the .hmi file. At the culmination of activity at this node, total administrative costs can be critiqued by printing the value of the variable admin_cost. This should equal the sum of all administrative activities needed plus the clinic visitation cost. | Model Statistics |
| Clinic Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "clinic consult" node is as advertised in the .hmi file. (NOTE: I believe this delay is statically defined as of now.) | Model Parameters |
| Clinic Submodel | Keep the previously built scenario. Set a break-point in the "clinic services" node. Ensure that the individual clinic service costs are accurately calculated based upon the clinical services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total service costs can be critiqued by printing the value of the variable tests_cost. This should equal the sum of all service activities needed. | Model Parameters |
| Clinic Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "clinic services" node is the sum of the delays of each service performed at this node. Each individual service delay is parameterized in the .hmi file. | Model Parameters |
| Clinic Submodel | Keep the previously built scenario. Set a break-point in the clinic_treatments node. Ensure that the individual clinic treatment costs are accurately calculated based upon the clinical treatments needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total treatment costs can be critiqued by printing the value of the variable treatments_cost. This should equal the sum of the cost of all treatment activities needed. | Model Parameters |

**E-SYSTEMS**

| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Clinic Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "clinic treatments" node is the sum of the delays of each treatment performed at this node. Each individual treatment delay is parameterized in the .hmi file. | Model Parameters |
| Clinic Submodel | Keep the previous scenario. Set up a breakpoint at the "clinic discharge" node. Ensure that the next event delay is appropriate such that at completion of the delay, the elapsed time since patient presentation is equal to the time specified in the next health care rule. | Database Query |
| Physician Office Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set up a breakpoint in the "enter physician office" node. Verify that each patient arriving at this node should do so by comparison with health care rules as defined in dbase.sim. Ensure the accounting of all patients arrive at this node. | Database Query |
| Physician Office Submodel | Verify that the actual delays for physician office admission and physician office triage accurately reflect the delay times requested in the physician office submodel portion of the parameter .hmi file. | Model Parameters |
| Physician Office Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set a breakpoint in the "services required" node within the physician office submodel domain. By using the debugger, ensure that each service, treatment, and administrative service required is accommodated for each patient who enters the physician office. As each "where next" loop is traversed, ensure that the unshared variable associated with the action performed is reset to 0. | Model Trajectory |

**E-SYSTEMS**

| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Physician Office Submodel | Keep the previously built scenario. Set a breakpoint in the "phy_off_admin" node. Ensure that the administrative costs are accurately calculated based upon the administrative services needed for the patient and the costs reflected in the parameter.hmi file. Also, ensure that the total administrative cost takes into account the physician office visit cost which is also a parameter in the .hmi file. At the culmination of activity at this node, total administrative costs can be critiqued by printing the value of the variable admin_cost. This should equal the sum of all administrative activities needed plus the physician office visitation cost. | Model Statistics |
| Physician Office Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the phy_off_admin node is as advertised in the .hmi file. (NOTE: I believe this delay is statically defined as of now.) | Model Parameters |
| Physician Office Submodel | Keep the previously built scenario. Set a breakpoint in the "phy_off_tests" node. Ensure that the individual physician office service costs are accurately calculated based upon the clinical services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total service costs can be critiqued by printing the value of the variable tests_cost. This should equal the sum of all test activities needed. | Model Parameters |
| Physician Office Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "phy_off_tests" node is the sum of the delays of each test performed at this node. Each individual test delay is parameterized in the .hmi file. | Model Parameters |
| Physician Office Submodel | Keep the previously built scenario. Set a breakpoint in the "phy_off_treatments" node. Ensure that the individual physician office treatment costs are accurately calculated based upon the clinical treatments needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total treatment costs can be critiqued by printing the value of the variable treatments_cost. This should equal the sum of the cost of all treatment activities needed. | Model Parameters |

**E-SYSTEMS**

| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Physician Office Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "phy_off_treatments" node is the sum of the delays of each treatment performed at this node. Each individual treatment delay is parameterized in the .hmi file. | Model Parameters |
| Physician Office Submodel | Keep the previous scenario. Set up a breakpoint at the "phy_off_discharge" node. Ensure that the next event delay is appropriate such that at completion of the delay, the elapsed time since patient presentation is equal to the time specified in the next health care rule. | Database Query |
| Hospital Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set up a breakpoint in the "enter hospital" node. Verify that each patient arriving at this node should do so by comparison with health care rules as defined in dbase.sim. Ensure the accounting of all patients arrive at this node. | Database Query |
| Hospital Submodel | Verify that the actual delays for hospital admission and hospital triage accurately reflect the delay times requested in the hospital submodel portion of the parameter .hmi file. | Model Parameters |
| Hospital Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set a breakpoint in the "services required" node within the hospital submodel domain. By using the debugger, ensure that each service, treatment, and administrative service required is accommodated for each patient who enters the hospital. As each day of medical execution occurs, ensure that the unshared variable associated with the action performed is reset to 0 and then reestablished to the services required on the next day. | Model Trajectory |

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| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Hospital Submodel | Keep the previously built scenario. Set a break-point in the hospital_administration node. Ensure that the administrative costs are accurately calculated based upon the administrative services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total administrative costs can be critiqued by printing the value of the variable admin_cost. This should equal the sum of the cost of all administrative activities needed. | Model Statistics |
| Hospital Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "hospital administrative" node is as advertised in the .hmi file. (NOTE: I believe this delay is statically defined as of now) | Model Parameters |
| Hospital Submodel | Keep the previously built scenario. Set a break-point in the "hospital services" node. Ensure that the individual hospital service costs are accurately calculated based upon the clinical services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total service costs can be critiqued by printing the value of the variable tests_cost. This should equal the sum of all test activities needed. | Model Parameters |
| Hospital Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "hospital services" node is the sum of the delays of each test performed at this node. Each individual test delay is parameterized in the .hmi file. | Model Parameters |
| Hospital Submodel | Keep the previously built scenario. Set a break-point in the "hospital treatments" node. Ensure that the individual hospital treatment costs are accurately calculated based upon the clinical treatments needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total treatment costs can be critiqued by printing the value of the variable treatments_cost. This should equal the sum of the cost of all treatment activities needed. | Model Parameters |

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| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Hospital Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the hospital treatments" node is the sum of the delays of each treatment performed at this node. Each individual treatment delay is parameterized in the .hmi file. | Database Query |
| Regional Medical Center Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set up a breakpoint in the "enter RMC" node. Verify that each patient arriving at this node should do so by comparison with health care rules as defined in dbase.sim. Ensure the accounting of all patients arrive at this node. | Database Query |
| Regional Medical Center Submodel | Verify that the actual delays for RMC admission and RMC triage accurately reflect the delay times requested in the regional medical center submodel portion of the parameter .hmi file. | Model Parameters |
| Regional Medical Center Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set a breakpoint in the "services required" node within the RMC submodel domain. By using the debugger, ensure that each service, treatment, and administrative service required is accommodated for each patient who enters the regional medical center. As each day of medical execution occurs, ensure that the unshared variable associated with the action performed is reset to 0 and then reestablished to the services required on the next day. | Model Trajectory |
| Regional Medical Center Submodel | Keep the previously built scenario. Set a breakpoint in the "RMC_administration" node. Ensure that the administrative costs are accurately calculated based upon the administrative services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total administrative costs can be critiqued by printing the value of the variable admin_cost. This should equal the sum of the cost of all administrative activities needed. | Model Statistics |

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| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Regional Medical Center Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "RMC_administration" node is as advertised in the .hmi file. (NOTE: I believe this delay is statically defined as of now) | Model Parameters |
| Regional Medical Center Submodel | Keep the previously built scenario. Set a break-point in the "RMC_Services" node. Ensure that the individual regional medical center service costs are accurately calculated based upon the clinical services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total service costs can be critiqued by printing the value of the variable tests_cost. This should equal the sum of all test activities needed. | Model Parameters |
| Regional Medical Center Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "RMC_Services" node is the sum of the delays of each test performed at this node. Each individual test delay is parameterized in the .hmi file. | Model Parameters |
| Regional Medical Center Submodel | Keep the previously built scenario. Set a break-point in the "RMC_Treatments" node. Ensure that the individual regional medical center treatment costs are accurately calculated based upon the clinical treatments needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total treatment costs can be critiqued by printing the value of the variable treatments_cost. This should equal the sum of the cost of all treatment activities needed. | Model Parameters |
| Regional Medical Center Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "RMC_Treatments" node is the sum of the delays of each treatment performed at this node. Each individual treatment delay is parameterized in the .hmi file. | Database Query |

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| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Diagnostic and Treatment Center Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set up a breakpoint in the "Enter DTC" node. Verify that each patient arriving at this node should do so by comparison with health care rules as defined in dbase.sim. Ensure the accounting of all patients arrive at this node. | Database Query |
| Diagnostic and Treatment Center Submodel | Verify that the actual delays for DTC admission and DTC triage accurately reflect the delay times requested in the diagnostic treatment center submodel portion of the parameter .hmi file. | Model Parameters |
| Diagnostic and Treatment Center Submodel | Establish a scenario where there exists one patient for each of the possible presentations for each condition. Set a breakpoint in the "services required" node within the DTC submodel domain. By using the debugger, ensure that each service, treatment, and administrative service required is accommodated for each patient who enters the diagnostic treatment center. As each day of medical execution occurs, ensure that the unshared variable associated with the action performed is reset to 0 and then reestablished to the services required on the next day. | Model Trajectory |
| Diagnostic and Treatment Center Submodel | Keep the previously built scenario. Set a breakpoint in the "DTC_administration" node. Ensure that the administrative costs are accurately calculated based upon the administrative services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total administrative costs can be critiqued by printing the value of the variable admin_cost. This should equal the sum of the cost of all administrative activities needed. | Model Parameters |
| Diagnostic and Treatment Center Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "DTC_administration" node is as advertised in the .hmi file. (NOTE: I believe this delay is statically defined as of now) | Model Parameters |

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| TEST ENTITY | TEST DESCRIPTION | TEST EMPHASIS |
|---|---|---|
| Diagnostic and Treatment Center Submodel | Keep the previously built scenario. Set a break-point in the "DTC_Services" node. Ensure that the individual diagnostic treatment center service costs are accurately calculated based upon the clinical services needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total service costs can be critiqued by printing the value of the variable tests_cost. This should equal the sum of all test activities needed. | Model Parameters |
| Diagnostic and Treatment Center Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "DTC_Services" node is the sum of the delays of each test performed at this node. Each individual test delay is parameterized in the .hmi file. | Model Parameters |
| Diagnostic and Treatment Center Submodel | Keep the previously built scenario. Set a break-point in the "DTC_Treatments" node. Ensure that the individual diagnostic treatment center treatment costs are accurately calculated based upon the clinical treatments needed for the patient and the costs reflected in the parameter .hmi file. At the culmination of activity at this node, total treatment costs can be critiqued by printing the value of the variable treatments_cost. This should equal the sum of the cost of all treatment activities needed. | Model Parameters |
| Diagnostic and Treatment Center Submodel | Keep the previous scenario and breakpoint. Ensure that the delay at the "DTC_Treatments" node is the sum of the delays of each treatment performed at this node. Each individual treatment delay is parameterized in the .hmi file. | Database Query |

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# Section 9: References

## 9.1 Section Overview

This section idenitifies the referenced materials and source documents utilized to evaluate the current state of the health care environment and conditions to be utilized in the initial Phase I evaluation of the Unit Cell Concept impact on health care. The information contained in these documents was used in the design, loading, and data construction of the model.

## 9.2 Provider-Related Operations

American Medical Association, *Physician Characteristics and Distribution in the U.S.*, American Medical Association, 1993.

**Description of Data:**
Yearly data on doctors of medicine (MD) only divided into three sections:
1) Trends: Medical specialty and metropolitan statistical area from 1970 -1992; cross tabulation of physician characteristics by professional activity, age, and sex; national trend data on primary care specialties, and patient care. Physician popultion ratios for selected years 1950 - 1992 are included as are ratios by state and specialty.
2) Characteristics: Cross-tabulations include sex, age, major professional activity, specialty, federal and non-federal employment.
3) Distribution: Geographic location by state and specialty and activity data for the nation as well as by states, census regions, divisions, MSA's and counties.

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American Medical Association, *Socioeconomic Characteristics of Medical Practice*, American Medical Association, 1994.

**Description of Data:**
An annual volume with studies and statistics based on information collected by the AMA on doctors of medicine only measures physician practice characteristics including physician income data for 1992; 1993 data on weeks and hours of practice; utilization of physician services; hospital utilization of physicians; fees for physicians; professional expenses of physicians and physician net income after expenses before taxes; physician services market trends; and managed care participation. Most data broken down by specialty. Some by census division.

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American Hospital Association, *Hospital Statistics*, American Hospital Association, 1993.

**Description of Data:**
Another annual publication that tracks the operational performance of all institutions that can legally call themselves hospitals and sub-divides them by type (federal, non-federal) ownership structure (private, public, profit, non-profit, etc.), size and manpower utilization, services and facilities provided. There is some discussion of costs per patient, but these are aggregate numbers only, not by disease. (Facilities and services included along with utilization, personnel/census, and

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finances/patient day in section IV).

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GAO, *Medical Malpractice: Estimated Savings and Costs of Federal Insurance at Health Centers*, GAO, September 1993.

**Description of Data:**
Discusses providing malpractice insurance to physicians who practice at community and migrant health centers as a strategy for keeping them open. These centers are in areas of the country with shortages in physicians and other health care providers.

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GAO, *Medical Malpractice: Maine's Use of Practice Guidelines to Reduce Costs*, GAO, October 1993.

**Description of Data:**
Medical malpractice promoted $15 billion in defensive medicine costs in 1989. Do practice guidelines help to control these wasteful procedures?

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Ernst & Young, *A Report of National Trends and Issues of Interest to Health Care Organizations*, Ernst & Young, November 1993.

**Description of Data:**
An overview of relevant concerns such as "legislation and trends," "accounting issues," "tax issues," etc. by far its best feature is its discussion of hospital operating indicators. Also available are some quoted hospital revenue and profit margins.

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Multivaried, *Hospital Trends*, Multivaried, 1993 and 1994.

**Description of Data:**
Trends that may not fit a specific topic of immediate concern but that may impact later, (i.e., what is the rate of the current shift to out-patient care? Study reveals downsizing causes more deaths and paperwork; etc.)

---

National Center for Health Statistics (NCHS), *Vital and Health Statistics* (24 monograph titles), National Center for Health Statistics, varies by monograph.

**Description of Data:**
Series 13: National Health Care Survey: these reports contain data on health resources and the public's utilization of those resources including ambulatory, hospital, and long-term care services based on data collected directly from health care provider records (see series 10 for related data).

Hospital discharge summary (Table of contents in section VI).

Utilization of non-federal short-stay hospitals by:
1) Demographic characteristics of patients.
2) Geographic region of hospital.
3) Conditions diagnosed.

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4) Surgical and non-surgical procedures performed.

National ambulatory care survey (Table of contents in section VII).

National utilization rates of office-based physicians by:
1) Physician practice characteristics, for primary as well as specialty including general practitio-ners, internists, pediatricians, and ob/gyn.
2) Patient characteristics.
3) Patient's reason for visit.
4) Diagnosis and treatment.

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Agency for Health Care Policy and Research; research note 17, *Clinical Classification for Health Policy Research: Discharge Statistics by Principal Diagnosis and Procedure: 1987*, Agency for Health Care Policy and Research, 1993.

**Description of Data:**
This research note serves two purposes:
1) Describes one procedure classification system and two diagnosis classification systems.
2) Provides descriptive statistics concerning hospital services received in the U.S. grouped by prin-cipal diagnosis and procedure.

---

National Center for Health Services Research; research note 10, *Hospital Cost and Utilization Project-2: Project Overview*, National Center for Health Services Research, July 1988.

**Description of Data:**
This research note describes the HCUP-2 project. It focuses primarily upon the most recent round of data collection, which covers period 1980-87.

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Hospital Cost and Utilization Project; research note 7, *Competition Among Hospitals: Market Structure and its Relation to Utilization, Costs and Financial Position*, Hospital Cost and Utiliza-tion Project, August 1985.

**Description of Data:**
Discusses and analyzes efforts to control health care costs by restructuring the nature of competi-tion in the marketplace.

---

Agency for Health Care Policy and Research (AHCPR), *Casemix Specialization in the Market for Hospital Services*, Agency for Health Care Policy and Research, August 1987.

**Description of Data:**
Discusses and analyzes "recent changes in case mix specialization and the relationship of these changes to hospital costs."

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Hospital Cost and Utilization Project; research note 9, *Case Mix and Treatment Patterns of Medic-aid and Privately Insured Psychiatric Patients in Short-Term General Hospitals*, Hospital Cost and Utilization Project, August 1985.

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**Description of Data:**
Analyzes the phenomenon of shorter stays for medicaid patients versus privately insured patients.

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National Center for Health Services Research: research note 11, *Trends in Hospitals A.L.O.S., Casemix, and Discharge Rates, 1980-85*, National Center for Health Services Research, April 1988.

**Description of Data:**
Discusses and analyzes the factors underlying the 20% decline in hospital occupancy rates witnessed between 1980-85. One typical finding: the shift has made hospitals even more dependent upon Medicaid because these patients usually require longer treatment periods.

There are dozens of national publications produced by the National Bureau of Health Statistics which address the health care concerns of specific sub groupings of the population.

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U.S. Census Bureau, *Bureau of Vital Statistics*, U.S. Census Bureau, 1993.

**Description of Data:**
Published annually, contains national data. Unsurprisingly, it often references one or another of the monographs published by the NCHS.
1) Census by state, region, metropolitan statistical area broken down by age, sex, and race.
2) Physician distribution by state and region further defined by field of expertise.
3) Incidence of most common diseases.
4) Major insurers.
5) Health care expenditures, both past and projected.

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Sunshine & Bansal, *Operational, Professional and Business Characteristics of Radiology Groups in the U.S.*, American College of Radiology, 1992.

**Description of Data:**
Straightforward with some good general statistics such as an average of 15,000 diagnostic examinations annually, etc.

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Sunshine & Bansal, *Hospital and Office Aractices of Radiology Groups*, American College of Radiology, 1991.

**Description of Data:**
Straightforward with some good general statistics.

---

Healey & Jacobson, *Common Medical Diagnoses: An Algorithmic Approach*, Saunders, 1994.

**Description of Data:**
A decision-tree approach to diagnosing using signs, symptoms, and diagnostic procedures in a logical, cost-effective manner. Includes citations validating the decision matrix. The algorithms lend themselves to easy (sic) simulation and involve the most common presenting conditions seen in a

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general practitioner's or internist's office.

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Agency for Health Care Policy and Research (AHCPR), *Clinical Practice Guidelines*, Agency for Health Care Policy and Research, multiple years.

**Description of Data:**
The AHCPR periodically releases recommended guidelines for the treatment of specific conditions (i.e., heart failure) and provides a corresponding algorithm to follow. Diagnostic tests are also included. The AHCPR has only existed since 1986, so only a few sets of guidelines have been released.

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HHS, *Executive Summary: Guidelines for the Diagnosis and Management of Asthma*, NIH, June 1991.

**Description of Data:**
An algorithmic approach to treatment of this disease from the home to the doctor to the hospital ER and ICU settings.

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## 9.2 Payer-Related Operations

Health Insurance Association of America, *Source Book of Health Insurance Data*, Health Insurance Association of America, 1992.

**Description of Data:**
An annual collection of statistical data on private health insurance in the U.S. compiled by HIAA's department of policy development and research. Includes the latest data to date on the major forms of insurance coverage including:
1) Managed care programs.
2) Medical care costs.
3) Utilization of the nation's medical facilities.
4) National morbidity and mortality trends.
(Table of contents in section VIII)

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Health Insurance Association of America, *Prevailing Health Care Charges System*, Health Insurance Association of America, 1992.

**Description of Data:**
Data collected on charges by geographical area of U.S. available only by subscription to certain organizations.

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## 9.3 Equity of Access

National Center for Health Statistics (NCHS), *Vital and Health Statistics* (24 monograph titles),

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National Center for Health Statistics, varies by monograph

**Description of Data:**
Also known as "the rainbow series," this is the largest and oldest national series on the topic (Series description in section V).

Series 3: Analytical and epidemiological studies. These reports carry the analyses further than the expository types of reports in the series.

Common beliefs about the rural elderly: what does the national data tell us?

In-depth analysis on the complex relationships between income, access, race, social networks, housing, and education on the overall health status of the rural elderly. Costs are also included.

Series 10: Data from the NHIS. Based on a continuing national house-hold survey, it contains statistics on:
1) Illness
2) Unintentional injuries
3) Disability
4) Use of hospitals, medical services, and other health services.
5) Wide range of special current topics covering many aspects of health behaviors, health status, and health care utilization.

Health of black and white americans, 1985-87.

In-depth comparisons of health status and utilization of health services, such as:
1) Number of yearly visits to the doctor.
2) Number of yearly hospitalizations.
3) Average length of stay.

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Funded by Health Care Finance Administration (HCFA) and The Agency for Health Care Policy and Research (AHCPR), *Rand Corporation Study*, 1994.

**Description of Data:**
Study suggests black and poor Medicare patients receive lower quality care.

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Berry & Seavey, *Assuring Access to Rural Health Services: The Case for Revitalizing Small Rural Hospitals*, Health Care Management Review, 1994, 19(2), 32-42.

**Description of Data:**
Many small hospitals play a critical role in ensuring access to basic health care services, and it is in the public interest for these hospitals to receive the necessary support to revitalize their capabilities.

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## 9.4 Patient-Related Operations

National Center for Health Statistics (NCHS), *Vital and Health Statistics* (24 monograph titles), National Center for Health Statistics, varies by monograph.

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**Description of Data:**
Also known as "the rainbow series," this is the largest and oldest national series on the topic (series description included).

Series 3: Analytical and epidemiological studies. These reports carry the analyses further than the expository types of reports in the series.

Health data on older americans: U.S., 1992.

Discusses their mortality, risk of institutionalization, and examines in-depth their health care use and its related costs.

Common beliefs about the rural elderly: what do national data tell us?

In-depth analysis on the complex relationships between income, access, race, social networks, housing and education on the overall health status of the rural elderly. Costs are also included.

Series 10: Data from the NHIS based on a continuing national household survey, it contains statistics on:
1) Illness
2) Unintentional injuries
3) Disability
4) Use of hospitals, medical services and other health services.
5) Wide range of special current topics covering many aspects of health behaviors, health status, and health care utilization.

Current estimates from the national health interview survey: 1992 (Table of contents included).

National rates of health care utilization as reported by the citizenry by age and sex regarding:
1) Number of yearly visits to the doctor.
2) Number of yearly hospitalizations.
3) Average length of stay.
4) Patient chief complaint.
5) Number of days unable to work.
6) Number of days bedridden.

Health characteristics of large metropolitan areas: U.S., 1988-1989, this project was partially motivated by the need to consider health service areas as possible primary sampling units (PSU's) for the NHIS and by the need to use health services areas to measure the availability of health resources (for example, per capita physicians and hospital beds), to study geographic variations in health care use, and to study the relationship between health care resources, the utilization of those resources, and health status.

Based on 1989 NHIS survey and includes data on the age distribution of the populations, restricted activity, bed disability, work and school days lost, respondent assessed health status, physician utilization, morbidity ratios, and more.

Impairments due to injuries: U.S., 1985-1987
Includes their rates, classification, limitation of activity, restricted activity days, and bed-disability days along with trended data.

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Dental services and oral health: U.S., 1989

Healthy People 2000 includes 16 oral health objectives and 20 subobjectives directed toward reduced oral disease, increased oral health screening, access to care, etc. This data set provides information that helps direct health promotion strategies.

Series 21: Data on natality, marriage, and divorce. Includes data not tracked in regular, monthly, or annual reports. Special analyses by health and demographic variables and geographic and trend analyses are included.

Trends and variations in first births to older women 1970-1986:

First births to women in their thirties have increased substantially since 1970, doubling, tripling, then quadrupling their levels in a 16-year data.

Birth and fertility rates by education: 1980-1985:

Measurements of fertility by age group, race, etc. will be used to populate the simulation's ob/gyn submodule.

---

Kizer, *Elderly California Discharges to Nursing Homes*, Dept. of Health Services, 1987.

**Description of Data:**
A study aimed at measuring the relationship between age and rate of referral to a nursing home, along with sex, race, and cause of hospitalization.

---

Kizer, *Elderly and Non-Elderly Emergency Room Generated Hospital Admissions in California*, 1986, Dept. of Health Services, 1989.

**Description of Data:**
A study aimed at measuring the proportion of hospital admissions originating in the ER for elderly and non-elderly. What was the spectrum of diseases seen?

---

Kizer, *Injuries Resulting in Admissions to California Hospitals*, 1985, Dept. of Health Services, 1989.

**Description of Data:**
A study of the under 21 age group measuring the magnitude of the problem as well as the types of injuries & their relative costs.

---

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## 9.5  Public Health Promotion

HHS: Public Health Service, *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*, Jones and Bartlett, 1992.

**Description of Data:**
This document contains a national strategy for significantly improving the health of the nation. It addresses the prevention of major chronic illnesses, injuries, and infectious diseases. It provides us with established, researched, health-promoting goals with references supporting the impact these objectives could have if attained.

Series 10:  Data from the NHIS: based on a continuing national household survey, contains statistics on:
1) Illness.
2) Unintentional injuries.
3) Disability.
4) Use of hospitals, medical services and other health services.
5) Wide range of special current topics covering many aspects of health behaviors, health status, and health care utilization.

Dental services and oral health: U.S., 1989

Healthy people 2000 includes 16 oral health objectives and 20 subobjectives directed toward reduced oral disease, increased oral health screening, access to care, etc. this data set provides information that helps direct health promotion strategies.

---

HCFA, *HCFA Introduces Consumer Information Strategy to Improve Healthcare*, Healthcare Financial Management, 1994.

**Description of Data:**
The first phase will motivate Medicare recipients to gets flu shots and/or mammography screenings, etc.  The program will build year after year to include such things as how to select from among managed care plans and rehab facilities.

---

McKnight, *Hospitals and the Health of their Communities*, Hospitals & Health Networks, January 5,1994.

**Description of Data:**
The author argues that the new health care paradigm must focus on every aspect of the community's health, including its economic soundness.

---

GAO, *Health Care Reform: School-Based Health Centers can Promote Access to Care*, GAO, May 1994.

**Description of Data:**
Our work suggests that school-based health centers (SBHC's) do improve children's access to health care.  SBHC's can help to overcome financial and non-financial barriers that currently limit access, including the lack of health insurance, transportation difficulties, and insufficient attention

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to the needs of adolescents.

___

## 9.6 Health Care Costing Estimate

Agency for Health Care Policy and Research; research note 19, *National Bill for Diseases Treated in U.S. Hospitals: 1987*, Agency for Health Care Policy and Research, February 1994.

**Description of Data:**
This research note provides national estimates of charges and discharges for diseases treated in short-stay, general-service, non-federal hospitals in the U.S. in 1987. Diagnoses are grouped by 185 summary diagnosis categories and are ranked from highest to lowest hospital charges.

___

Health Care Finance Review, *National Health Expenditures, 1991, Health Care Finance Review*, Winter 1992.

**Description of Data:**
Spending for health care rose to 751.8 billion in 1991, an increase of 11.4% from the 1990 level. It was 13.2% as a share of gross domestic product, up from 12.2% in 1990. The health care sector exhibited strong growth, despite slow growth in the overall economy. Reasons why are explored.

___

Health Affairs, *Health Spending by State, Health Affairs*, Fall 1993.

**Description of Data:**
A new data set from HCFA gives estimates of state spending for hospital care, physician services, and retail purchases of prescription drugs, which together account for 70% of health expenditures nationwide. analysis of these data, which are the first uniform state data to be produced in nearly ten years, shows considerable variation among states and among regions in health spending. The New England and Mideast regions show consistently higher spending levels for all three categories; the Southwest and Rocky Mountain regions spent the smallest (as much as 17% below the national average).

___

## 9.7 Cost Effectiveness and Quality

Goldfeld, Pine, Pine, *Measuring and Managing Health Care Quality*, Aspen, 1993.

**Description of Data:**
Procedures, protocols, and techniques for assessing quality. Introduces four groups of techniques for internal quality monitoring and improvement:
1) Measuring clinical outcomes.
2) Obtaining information from patients.
3) Using a team approach to examine processes of care.
4) Developing protocols.

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Excellent reference with examples.

Neumann & Johannesson, *From Principle to Practice: Using Cost-Effectiveness Analysis*, Health Affairs, Summer 1994.

**Description of Data:**
The contents of this quarterly publication were devoted to the topic of medical innovations. This specific article is most instructive. "This commentary focuses on the challenges involved for public payers and what we can realistically expect a cost-effectiveness criterion to accomplish."

Other related articles:
"Regulation of Drugs and Devices"
"Perspective: Impact of Technology on Health Care"
"Perspectives on Technology Assessment"
"Technology and Health Reform: A Legislative Perspective"

Rosenstein, *Cost-Effective Health Care: Tools for Improvement*, Health Care Management Review, 1994, 19(2), 53-61.

**Description of Data:**
An evaluation of the current status of the cost-effectiveness effort.

As health care payers begin to shift financial risk and accountability onto the shoulders of the health care providers, it will become imperative for hospitals and physicians to improve and document efficiencies of care. This article addresses the need for information analysis required that lead to efficiencies in the process and outcomes of care.

Morrissey, *Rural Homecare Effectiveness to be Studied, Modern Healthcare*, Nov 22, 1993.

**Description of Data:**
The state of home care for the rural elderly is the prime focus of a $2-4m year evaluation by AHCPR.

U.S. News and World Report, *America's Best Hospitals, U.S. News and World Report*, July 18, 1994.

**Description of Data:**
Helping consumers find the best hospital care by 16 specialties; by region.

Multiple Sources, *The Clinton Plan*, Multiple Sources, 1994.

**Description of Data:**
The plan with various evaluators' comments.

Ernst & Young, *State Health Care Reform: Not Waiting on Washington*, Ernst & Young, July 1994.

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**Description of Data:**
Discusses the varied approaches states have taken to address the health care challenge. Nine different state's plans are reviewed and compared.

---

Baker & Helsel, *Using Provider Practice Profiles as Preventive Care for Medical Costs*, Infocare, June 1994.

**Description of Data:**
Developed their own guidelines (patterns of treatment) and used them to reduce the incidence of physician claims they rejected. Helping consumers find the best hospital care by 16 specialties; by region.

---

## 9.8 Diagnostic Imaging

Modern Healthcare, *Hospitals Slowing Purchases of MRI's --- Survey*, Modern Healthcare, Nov. 29, 1993.

**Description of Data:**
Status of imaging equipment in the U.S.

The nation's hospitals are keeping their MRI equipment longer and instead are investing in equipment used to diagnose heart and vascular disease.

---

Modern Healthcare, *FTC ok's Calif. Radiology Network*, Modern Healthcare, Dec. 13, 1993.

**Description of Data:**
Addresses anti-trust issues germane to networking.

---

## 9.9 Diagnosis-Related Group (DRG)

Health Care Investment Analysts, Inc., *25 Most Frequent DRG's*, Healthweek, April 22, 1991.

**Description of Data:**
Ranked by all medicare inpatient discharges, FY 1989.

---

Averill, et al, *Design of a Prospective Payment Classification System for Ambulatory Care*, Health Care Financial Review, Fall 1993.

**Description of Data:**
Reports the results of simulating the use of ambulatory patient groups (APG's) in a prospective payment system. In the process, they provide data trends on the types of emergency room patients seen and explain their simulation model.

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## 9.10 Informatics

O'Connor, *The Consumer Revolution Arrives*, Infocare (Supplement of Healthcare Networks), June 1994.

**Description of Data:**
An evaluation of the importance of using information technology as a means of improving customer service so as to attract, educate, and retain satisfied health care consumers.

---

GAO, *Benefits and Barriers to Automated Medical Records*, GAO, May 6, 1991.

**Description of Data:**
An assessment of the importance of information technology to controlling the cost and improving the health care services to the public. The report highlights technology issues that should be considered in weighing health care reform proposals.

---

John Silva, M.D., *Health Care Reform: A Strategist's Guide*, Healthcare Information Management, Winter 1994.

**Description of Data:**
A quarterly publication, this issue is fully devoted to the impact contemplated reforms might have on the evolution of hospital/healthcare information systems. Titles include:

"Elements of a National Health Information Infrastructure"
"Cost Savings from Information Technology in U.S. Health Care Reform"
"Insights from Modeling"
"Computer Supported Coordination of Medical and Social Services"
"IntegratingInformation Systems to Support Regional Health Care Organizations"

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Tan & Hanna, *Integrating Health Care with Information Technology: Knitting Patient Information Through Networking*, Health Care Management Review, 1994, 19(2), 72-80.

**Description of Data:**
Systematic, detailed planning is the key to managing the development of the sophisticated information systems we need in order to achieve improvements in efficiency and effectiveness.

---

Griffith, Smith & Wheeler, *Continuous Improvement of Strategic Information Systems: Concepts and Issues*, Health Care Management, 1994, 19(2), 43-52.

**Description of Data:**
The authors consider several problem areas on the current frontier of strategic information systems development and propose solutions that for the most part are expedient and pragmatic.

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## 9.11 Failings of the Current Health Care System

Government Accounting Office (GAO), *Health Care Reform: How Proposals Address Fraud and Abuse*, Government Accounting Office, March 17, 1994.

**Description of Data:**
In comparing the manner in which the current reform proposals addressed the weaknesses in health care, this report enumerates those weaknesses and suggests mechanisms for their control and elimination.

Public Citizen, *Worst Pills, Best Pills II*, Public Citizen, 1994.

**Description of Data:**
Champions the call for better mechanisms for prescribing drugs to the elderly and cites numerous detrimental consequences of inappropriate drug assignments (i.e., people over 60 comprise only a sixth of the total population, but ingest over 40% of all prescribed medications, and 16,000 car crashes a year are due to adverse drug reactions.)

Burner, Waldo, McKusick, *National Health Expenditures Projections Through 2030*, Health Care Financing Review, Fall 1992.

**Description of Data:**
In-depth and scholarly. Trends and projects health expenditures in greater detail than the CBO source cited next.

Congressional Budget Office (CBO), *Trends in Health Care Spending*, Congressional Budget Office, June 1993.

**Description of Data:**
Trends and projects health expenditures in general as well as drugs and other medical non-durables. Dated but still useful.

CBO, *Projections of National Health Expenditures: 1993*, CBO, October 1993.

**Description of Data:**
Trends and projects health expenditures in general.

GAO, *Greater Investment in Claims Review Would Save Millions*, GAO, March 1994.

**Description of Data:**
An assessment of the need for improvements in medicare claims.

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GAO, *Medicaid: A Program Highly Vulnerable to Fraud*, GAO, February 1994.

**Description of Data:**
The extent of the fraud is difficult to measure, but some state officials believe it is as high as 10%, about $15 billion.

GAO, *Inconsistent Denial Rates for Medical Necessity Across Six Carriers*, GAO, March 1994.

**Description of Data:**
Medicare is not a local initiative. It is a national program under which beneficiaries should not receive different benefits solely because their place of residence differs. But they do, nonetheless.

## 9.12 Managed Care

Ernst & Young, *Monitoring Performance*, Ernst & Young, August 1994.

**Description of Data:**
Describes health plan employer data and information set (HEDIS), a software package that simplifies comparisons between otherwise disparate managed plans. The issue is one of determining which plan yields the highest quality for invested premium dollar. Because managed care plans lack a uniform reporting tool, comparisons have been difficult at best.

Schlackman, *Evolution of a Quality Based Compensation Model: The Third Generation*, American College of Medical Quality, Summer 1993.

**Description of Data:**
Written by a medical director of a managed care plan, this article chronicles how they successfully combined physician compensation with quality care.

GAO, *Managed Health Care: Effect on Employer's Cost's Difficult to Measure*, GAO, multiple in 1994.

**Description of Data:**
In its effort to explain why there is still no clear cut answer to the question of managed care's cost-effectiveness, these articles explains why medical cost accounting in general is so hard to implement.

Deloitte & Touche, *The Fading Stand Alone Hospital, Hospital and Health Networks*, June 20, 1994.

**Description of Data:**
A survey of hospital executives reveals they expect a surge in regional affiliations in preparation for managed care growth and market reform.

GAO, *Health Care in Hawaii: Implications for National Reform*, GAO, Feb. & March 1994.

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**Description of Data:**
For almost 20 years, Hawaii has been a leader in the effort to achieve universal access to health care. As a result, Hawaii has the highest level of insurance coverage of any state in the union. This report examines Hawaii's experience with providing access to health insurance and health services, its experience with related costs, and the effects the system has had on the state's small businesses and health care providers.

Multivaried, *Managed Health Care: Trends*, Multivaried, 1993-1994.

**Description of Data:**
Various and sundry snapshot quotations about different aspects of managed care.

## 9.13 Morbidity and Mortality

Centers for Disease Control (CDC), *Morbidity and Mortality Weekly Report (MMWR)*, Centers for Disease Control, weekly.

**Description of Data:**
Weekly tabulation of the incidence of selected contagious or insect-borne diseases. The CDC tracks the incidence of a multitude of diseases, reporting these to the public health department, the NIH, and the general public. Currently working to identify the specific costs related to these disease states. The Public Health Department releases estimated costs for such things as heart disease but usually it is aggregate data that does not lend itself to more specific analysis (i.e., no age, sex, or regional breakdown) or it is outdated. It is productive to scan sources for specifics like this one: "The Journal of the American Medical Association reports in their July 23, 1993 issue that the maximum AIDS cost per case is $119,000."

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# Appendix A
# Model Inputs and Outputs

## A.1  Model Parameter Values

### A.1.1  Current Health Care System - District 1, District 4, District 7
*Cost is in dollars
*Time units are hours

**Home Submodel**

| | |
|---|---|
| Submodel Name | Home[0] |
| condition 1 treatment cost  (dollars) | 0.5 |
| condition 1 recovery cost | 25 |
| condition 2 treatment cost | 0.5 |
| condition 2 recovery cost | 150 |
| condition 3 treatment cost | 0.5 |
| condition 3 recovery cost | 150 |
| condition 4 treatment cost | 0.5 |
| condition 4 recovery cost | 150 |
| condition 5 treatment cost | 0.5 |
| condition 5 recovery cost | 150 |
| Administration Services | 201326592 |
| Tests Available values: | 0 |
| Treatments Available | 3 |
| HOME: log file name | home.log |
| HOME: log trace options - see physician_evaluation.h | 0 |
| HOME: log start time | 0 |
| HOME: log end time | 480 |

**Physician Office Submodel**

| Name | Primary Care Physician[0] |
|---|---|
| new admit delay          (hours) | 0.25 |
| repeat admit delay | 0.15 |
| triage delay | 0.15 |
| simple discharge delay | 0.1 |
| moderate discharge delay | 0.2 |
| complex discharge delay | 0.3 |
| Admin Primary Care Office Visit Cost | 75 |
| Admin Remote Specialist Consult Cost | 70 |
| Services Standard Physical Delay | 1 |
| Services Standard Physical Cost | 225 |
| Services CAT Scan Delay | 0.75 |
| Services CAT Scan Cost | 1200 |
| Services CBC Delay | 0.1 |

**E-SYSTEMS**

| | |
|---|---|
| Services CBC Cost | 34 |
| Services RSV Culture Delay | 0.25 |
| Services RSV Culture Cost | 46.5 |
| services EKG delay time | 0.25 |
| services EKG cost | 75 |
| services o2 sat delay time | 0.2 |
| services o2 sat cost | 300 |
| services Cardio-Respiratory monitor cost | 125 |
| services mri delay time | 0.75 |
| services mri cost | 850 |
| services smac12 delay time | 0.25 |
| services smac12 cost | 86.5 |
| services spu_spec delay time | 0.1 |
| services spu_spec cost | 46.5 |
| services X-Ray delay time | 0.25 |
| services x-ray cost | 55 |
| services ABG delay time | 0.25 |
| services ABG cost | 55 |
| services smac18 delay time | 0.2 |
| services smac18 cost | 127 |
| services ECHO delay time | 1 |
| services ECHO cost | 350 |
| services Cardiac Enzyme delay time | 0.25 |
| services Cardiac Enzyme cost | 67 |
| services HGB HCT delay time | 0.25 |
| services HGB HCT cost | 28.5 |
| services Liver Function delay time | 0.25 |
| services Liver Function cost | 134 |
| services Stress Test delay time | 2 |
| services Stress Test cost | 800 |
| services Urinalysis time | 0.25 |
| services Urinalysis cost | 14.5 |
| services Serum Creatinine time | 0.25 |
| services Serum Creatinine cost | 44 |
| services Serum K time | 0.25 |
| services Serum K cost | 40 |
| services Uric Acid time | 0.25 |
| services Uric Acid cost | 35.5 |
| services Blood Sugar time | 0.25 |
| services Blood Sugar cost | 44 |
| services Lipid Profile time | 0.25 |
| services Lipid Profile cost | 90 |
| treatments antibiotic delay time | 0.25 |
| treatments antibiotic cost | 30 |
| treatments antiviral delay time | 0.25 |
| treatments antiviral cost | 70 |
| treatments rehydration delay time | 0 |
| treatments rehydration cost | 40 |
| treatments Ventilation delay time | 0 |
| treatments Ventilation cost | 0 |
| treatments Respiratory Therapy delay time | 1 |

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| | |
|---|---|
| treatments Respiratory Therapy cost | 25 |
| treatments IV  delay time | 0 |
| treatments IV cost | 50 |
| treatments O2 delay time | 1 |
| treatments O2 cost | 12 |
| treatments Smoking Counseling delay time | 0.4 |
| treatments Smoking Counseling cost | 25 |
| treatments Weight Loss Counseling time | 0.4 |
| treatments Weight Loss Counseling cost | 25 |
| treatments Nutrition delay time | 0.4 |
| treatments Nutrition cost | 25 |
| treatments Stress Management delay time | 0.4 |
| treatments Stress Management cost | 25 |
| Admin Services | 4 |
| Tests Available | 16665562 |
| Treatments | 8095 |
| PHYSICIAN OFFICE: log file name | physician.log |
| PHYSICIAN OFFICE: log trace options - see hospital.h | 0 |
| PHYSICIAN OFFICE: log start time | 0 |
| PHYSICIAN OFFICE: log end time | 480 |

## Hospital Submodel

| Name | Hospital[0] |
|---|---|
| new admit delay | 0.25 |
| repeat admit delay | 0.15 |
| triage delay | 0.15 |
| simple discharge delay | 0.1 |
| moderate discharge delay | 0.2 |
| complex discharge delay | 0.3 |
| Admin Specialist Remote Cost | 70 |
| Admin Specialist Visit Cost | 100 |
| Admin Floor Room and Board Cost | 500 |
| Admin ICU Room and Board Cost | 1000 |
| Admin CCU Room and Board Cost | 1000 |
| Admin ER Cost - All Tests/Treatments | 50 |
| Services Standard Physical Delay | 15 |
| Services Standard Physical Cost | 225 |
| Services CAT Scan Delay | 0.75 |
| Services CAT Scan Cost | 1200 |
| Services CBC Delay | 0.1 |
| Services CBC Cost | 34 |
| Services RSV Culture Delay | 0.25 |
| Services RSV Culture Cost | 46.5 |
| services EKG delay time | 0.25 |
| services EKG cost | 75 |
| services O2 sat delay time | 0.2 |
| services O2 sat cost | 300 |
| services Cardio-Resp monitor cost | 125 |
| services mri delay time | 0.75 |

**E-SYSTEMS**

| | |
|---|---|
| services mri cost | 850 |
| services smac12 delay time | 0.25 |
| services smac12 cost | 86.5 |
| services spu_spec delay time | 0.1 |
| services spu_spec cost | 46.5 |
| services x-ray delay time | 0.25 |
| services x-ray cost | 55 |
| services ABG delay time | 0.25 |
| services ABG cost | 55 |
| services smac18 delay time | 0.2 |
| services smac18 cost | 127 |
| services ECHO delay time | 1 |
| services ECHO cost | 350 |
| services Cardiac Enzyme delay time | 0.25 |
| services Cardiac Enzyme cost | 67 |
| services HBGG HCT delay time | 0.25 |
| services HBG HCT cost | 28.5 |
| services Liver Function delay time | 0.25 |
| services Liver Function cost | 134 |
| services Stress Test delay time | 2 |
| services Stress Test cost | 800 |
| services Urinalysis time | 0.25 |
| services Urinalysis cost | 14.5 |
| services Serum Creatinine time | 0.25 |
| services Serum Creatinine cost | 44 |
| services Serum K time | 0.25 |
| services Serum K cost | 40 |
| services Uric Acid time | 0.25 |
| services Uric Acid cost | 35.5 |
| services Blood Sugar time | 0.25 |
| services Blood Sugar cost | 44 |
| services Lipid Profile time | 0.25 |
| services Lipid Profile cost | 90 |
| treatments antibiotic delay time | 0 |
| treatments antibiotic cost | 120 |
| treatments antiviral delay time | 0 |
| treatments antiviral cost | 650 |
| treatments rehydration delay time | 0 |
| treatments rehydration cost | 160 |
| treatments Ventilation delay time | 24 |
| treatments Ventilation cost | 1500 |
| treatments Respiratory Therapy delay time | 1 |
| treatments Respiratory Therapy cost | 125 |
| treatments IV delay time | 0 |
| treatments IV cost | 100 |
| treatments O2 delay time | 24 |
| treatments O2 cost | 225 |
| treatments Smoking Counseling delay time | 0.5 |
| treatments Smoking Counseling cost | 75 |
| treatments Weight Loss Counseling time | 0.5 |
| treatments Weight Loss Counseling cost | 75 |

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| | |
|---|---|
| treatments Stress Management delay time | 0.5 |
| treatments Stress Management cost | 75 |
| treatments Nutrition delay time | 0.5 |
| treatments Nutrition cost | 75 |
| Administration | 248 |
| Tests in Hospital | 16777215 |
| Treatments | 8191 |
| HOSPITAL: log file name | hospital.log |
| HOSPITAL: log trace options | 0 |
| HOSPITAL: log start time | 0 |
| HOSPITAL: log end time | 480 |

### A.2.2 Future Health Care System - District 1, District 4, District 7

**Home Submodel**

| | |
|---|---|
| Submodel Name | Home[0] |
| condition 1 treatment cost | 0.5 |
| condition 1 recovery cost | 25 |
| condition 2 treatment cost | 0.5 |
| condition 2 recovery cost | 150 |
| condition 3 treatment cost | 0.5 |
| condition 3 recovery cost | 150 |
| condition 4 treatment cost | 0.5 |
| condition 4 recovery cost | 150 |
| condition 5 treatment cost | 0.5 |
| condition 5 recovery cost | 150 |
| Administration Services | 201326592 |
| Tests Available values: | 0 |
| Treatments Available | 3 |
| HOME: log file name | home.log |
| HOME: log trace options | 1 |
| HOME: log start time | 0 |
| HOME: log end time | 480 |

**Clinic Submodel**

| | |
|---|---|
| Name | Primary Care Clinic[0] |
| new admit delay | 0.25 |
| repeat admit delay | 0.15 |
| triage delay | 0.15 |
| simple discharge delay | 0.1 |
| moderate discharge delay | 0.2 |
| complex discharge delay | 0.3 |
| Admin Mini-Clinic Co-Payment | 10 |
| Admin Remote Primary Care Consult Cost | 35 |
| Admin Remote Specialist Consult Cost | 70 |
| Services Standard Physical Delay | 15 |
| Services Standard Physical Cost | 110 |
| Services CAT Scan Delay | 0.75 |
| Services CAT Scan Cost | 1200 |
| Services CBC Delay | 0.1 |

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| | |
|---|---|
| Services CBC Cost | 17 |
| Services RSV Culture Delay | 0.25 |
| Services RSV Culture Cost | 23.25 |
| services EKG delay time | 0.25 |
| services EKG cost | 34 |
| services o2 sat delay time | 0.2 |
| services o2 sat cost | 150 |
| services Cardio-Resp monitor cost | 65 |
| services mri delay time | 0.75 |
| services mri cost | 850 |
| services smac12 delay time | 0.25 |
| services smac12 cost | 43.25 |
| services spu_spec delay time | 0.1 |
| services spu_spec cost | 23.25 |
| services x-ray delay time | 0.25 |
| services x-ray cost | 26 |
| services ABG delay time | 0.25 |
| services ABG cost | 55 |
| services smac18 delay time | 0.2 |
| services smac18 cost | 65 |
| services ECHO delay time | 1 |
| services ECHO cost | 350 |
| services Cardiac Enzyme delay time | 0.25 |
| services Cardiac Enzyme cost | 67 |
| services HGG HCT delay time | 0.25 |
| services HGB HCT cost | 14.25 |
| services Liver Function delay time | 0.25 |
| services Liver Function cost | 134 |
| services Stress Test delay time | 2 |
| services Stress Test cost | 800 |
| services Urinalysis time | 0.25 |
| services Urinalysis cost | 7.25 |
| services Serum Creatinine time | 0.25 |
| services Serum Creatinine cost | 22 |
| services Serum K time | 0.25 |
| services Serum K cost | 20 |
| services Uric Acid time | 0.25 |
| services Uric Acid cost | 17.25 |
| services Blood Sugar time | 0.25 |
| services Blood Sugar cost | 22 |
| services Lipid Profile time | 0.25 |
| services Lipid Profile cost | 45 |
| treatments antibiotic delay time | 0 |
| treatments antibiotic cost | 15 |
| treatments antiviral delay time | 0 |
| treatments antiviral cost | 35 |
| treatments rehydration delay time | 1 |
| treatments rehydration cost | 20 |
| treatments Ventilation delay time | 0 |
| treatments Ventilation cost | 0 |
| treatments Respiratory Therapy delay time | 1 |

**E-SYSTEMS**

| | |
|---|---|
| treatments Respiratory Therapy cost | 25 |
| treatments IV  delay time | 0 |
| treatments IV cost | 25 |
| treatments O2 delay time | 1 |
| treatments O2 cost | 12 |
| treatments Smoking Counseling delay time | 0.4 |
| treatments Smoking Counseling cost | 25 |
| treatments Weight Loss Counseling time | 0.4 |
| treatments Weight Loss Counseling cost | 25 |
| treatments Stress Management delay time | 0.4 |
| treatments Stress Management cost | 25 |
| treatments Nutrition delay time | 0.4 |
| treatments Nutrition cost | 25 |
| Admin Services | 3 |
| Tests Available | 16665566 |
| Treatments Available | 8095 |
| CLINIC: log file name | clinic.log |
| CLINIC: log trace options | 9 |
| CLINIC: log start time | 0 |
| CLINIC: log end time | 480 |

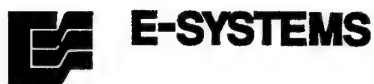**Physician Office Submodel**

Refer to Current System Parameter Values

**Hospital Submodel**

Refer to Current System Parameter Values

## A.2  Sample Graphical Scenarios

See attached.

**E-SYSTEMS**

## A.3  Sample Unit Cell Custom Report

Unit Cell Custom Report
25000.00 HOUR RUN
1041.67 DAY RUN
(execution complete for 937.00 days)

System Routing Statistics

System_Routing[0]

|  | Mean | Standard Deviation | Minimum | Maximum | Number of Occurrences |
|---|---|---|---|---|---|
| Overall Time in System (days) | 18.1804 | 75.5600 | 4.0000 | 573.0000 | 65609 |

Patient Time in System By Condition

|  | Mean | Standard Deviation | Minimum | Maximum | Number of Occurrences |
|---|---|---|---|---|---|
| Condition1_Pneumococcal (days) | 12.3736 | 1.6246 | 10.0000 | 14.0000 | 273 |
| Condition2_RSV (days) | 7.1856 | 1.0926 | 6.0000 | 12.0000 | 404 |
| Condition3_MI (days) | 454.2105 | 5.6829 | 447.0000 | 462.0000 | 95 |
| Condition4_Hypertension (days) | 573.0000 | 0.0000 | 573.0000 | 573.0000 | 1130 |
| Condition5_Influenza (days) | 7.7837 | 5.2036 | 4.0000 | 20.0000 | 63707 |

Patient Cost in System By Condition

|  | Mean | Standard Deviation | Minimum | Maximum | Number of Occurrences |
|---|---|---|---|---|---|
| Condition1_Pneumococcal Cost ($) | 7454.74 | 15776.17 | 285.02 | 54702.22 | 273 |
| Condition2_RSV Cost ($) | 12309.58 | 4644.20 | 10850.62 | 30133.17 | 404 |
| Condition3_MI Cost ($) | 53862.31 | 40937.04 | 13316.32 | 135986.62 | 95 |
| Condition4_Hypertension Cost ($) | 7134.24 | 0.00 | 7134.24 | 7134.24 | 1130 |
| Condition5_Influenza Cost ($) | 399.80 | 29.80 | 376.52 | 460.52 | 63707 |

| | |
|---|---|
| Total number of patients with Condition1_Pneumococcal: | 273 |
| Total Number Mild Cases: | 112 |
| Total Number Moderate Cases: | 134 |
| Total Number Sever Cases: | 27 |
| Deaths associated with Condition1_Pneumococcal: | 27 |

**E-SYSTEMS**

## A.4  Sample Graphical Output

See attached.

**E-SYSTEMS**

# Appendix B: Glossary

| Term | Definition |
|------|------------|
| **actuary** | Accredited, insurance mathematician who calculates premium rates, reserves, and dividends and prepares statistical studies and reports. |
| **administrative services only (aso) agreement** | Contact for the provision of certain services to a group employer, eligible group, trustee, etc., by an insurer or its subsidiary. Such services often include actuarial activities, benefit plan design, claim processing, data recovery and analysis, employee benefits communication, financial advice, medical care conversions, preparation of data for reports to government units, and stop-loss coverage. |
| **adverse selection** | Tendency of poorer-than-average health risks to apply for or maintain insurance coverage. |
| **age limits** | Stipulated and maximum ages below and above which the company will not accept applications or may not renew policies. |
| **alternate delivery system** | Provision of health services in settings more cost-effective than an in-patient, acute-care hospital, such as skilled and intermediary nursing facilities, hospice programs, and in-home services. |
| **ambulatory care** | Medical services provided on a out-patient (non-hospitalized) basis. Services may include diagnosis, treatment, surgery, and rehabilitating. |
| **benefit** | Amount payable by the insurance company to a claimant, assignee, or beneficiary when the insured suffers a loss covered by the policy. |
| **black box approach** | Simulation of the system is based on observable input and output of the system but the internal structure is unknown. |
| **blanket medical expense** | A provision that entitles the insured person to collect up to a maximum established in the policy for all hospital and medical expenses incurred, without any limitations on individual types of medical expenses. |
| **Blue Cross** | Third-party payer corporation providing subsidy for the cost of hospital care in a defined geographic area. |

**E-SYSTEMS**

| Term | Definition |
|------|-----------|
| **Blue Shield** | Third-party payer corporation providing subsidy for the cost of surgery and other items of medical care in a defined geographic area. |
| **capitation** | Method of payment for health services in which a physician or hospital is paid a fixed amount for each person served regardless of the actual number or nature. |
| **claim** | Demand to the insurer or on behalf of an insured person for the payment of benefits under a policy. |
| **co-insurance** | Arrangement by which the insurer and the insured share, in a specific ratio, payment for losses covered by the policy, after the deductible is met. |
| **comprehensive medical expanse insurance** | Form of health insurance that provides, in one policy, protection for both basic hospital expense and major medical expense coverages. |
| **contributory plan** | Group insurance plan under which the insured shares in the cost of the plan with the policyholder. |
| **conventional health plan** | Plan that provides all benefits under insurance policies and issues certificates containing the insurance company's guarantees to covered persons. |
| **coordination of benefits (COB)** | Method of integrating benefits payable under more than one health insurance plan so that the insured's benefits from all sources do not exceed 100 percent of allowable medical expenses or eliminate appropriate patient incentives to contain costs. |
| **cost containment** | Control or reduction of inefficiencies in the consumption, allocation, or production of health-care services that contribute to higher than necessary costs. Inefficiencies in consumption can occur when health services are inappropriately utilized; inefficiencies in allocation exist when health services could be delivered in less costly settings without loss of quality; and inefficiencies in production exist when the costs of producing health services could be reduced by using a different combination of resources. |
| **diagnosis-related groups (DRG)** | System of determining specific reimbursement fees based on medical diagnosis of a patient. |

**E-SYSTEMS**

| Term | Definition |
|---|---|
| disability | Physical or mental condition that makes an insured person incapable of performing one or more occupational duties either temporarily (short term), long-term, or totally (total disability). |
| discrete-event simulation | Modeling and analysis of the results obtained by generating random events at different points in time in a digital computer model of the system.  Changes in variables take place instantaneously in discrete steps. |
| evidence of insurability | Any statement or proof of a person's physical condition and/or other factual information affecting acceptability for insurance.  Required in group insurance only in specific situations: failure of an eligible person to enroll during the open enrollment period; for reinstatement after having previously withdrawn from the plan; when receiving an overall maximum benefit; or when applying for excess amounts of group life or disability insurance. |
| exclusions (exceptions) | Specified conditions or circumstances, listed in the policy, for which the policy will not provide benefits. |
| exclusive provider organization (EPO) | People who belong to an EPO must receive their care from affiliated providers; services rendered by unaffiliated providers are not reimbursed. |
| experience | Relationship, usually expressed as a percent or ratio, of claims to premium for a stated period. |
| experience rating | Process of determining the premium rate for a group risk based wholly or partially on that risk's experience. |
| experience refund | Amount of premium returned by an insurer to a group policyholder when the financial experience of a particular group (or the experience refund class to which the group belongs) has been more favorable than the premiums collected from the group anticipated. |
| health insurance | Types of coverage providing for the payment of benefits as a result of sickness or injury.  Includes insurance for losses from accident, disability, medical expense; or accidental death and dismemberment. |
| health maintenance organization (HMO) | Organization that provides for a wide range of comprehensive health care services for a specified group at a fixed periodic prepayment. |

**E-SYSTEMS**

| Term | Definition |
|---|---|
| hospice | Concept of care provided to terminally ill patients and their families that emphasizes emotional needs and coping with pain and death rather than cure. |
| hospital indemnity insurance | Form of health insurance that provides a stipulated daily, weekly, or monthly payment to an insured during hospital confinement, without regard to the actual expense of the confinement. |
| hospital medical insurance | A term used to indicate protection that provides benefits for the cost of any or all of the numerous health care services normally covered under various health care plans. |
| incurred claims | Incurred claims equal the claims paid during the policy year plus the claim reserves as of the end of the policy year, minus the corresponding reserves as of the beginning of the policy year. The difference between the year end and beginning of the year claim reserves is called the increase in reserves and may be added directly to the paid claims to produce the incurred claims. |
| insurance | Plan of risk management that, for a price, offers the insured an opportunity to share the costs of possible economic loss through an entity called an insurer. |
| legal reserve | Minimum reserve that a company must keep to meet future claims and obligations as they are calculated under the state insurance code. |
| long-term care | Continuum of maintenance, custodial, and health services to the chronically ill or disabled. Services may be provided on an in-patient (rehabilitation facility, nursing home, mental hospital), out-patient, or at-home basis. |
| long-term disability income insurance (LTD) | Benefits plan that helps replace earned income lost through inability to work because of disability caused by an accident or illness. |
| major medical expense insurance | Form of health insurance that provides benefits for most types of medical expense up to a high maximum benefit. Such contracts may contain internal limits and usually are subject to deductibles and co-insurance. |

**E-SYSTEMS**

| Term | Definition |
|---|---|
| managed care | Those systems that integrate the financing and delivery of appropriate health care services to covered individuals by means of arrangements with selected providers to furnish a comprehensive set of healthcare services to members; explicit criteria for the selection of health care providers; formal programs for on-going quality assurance and utilization review; and significant financial incentives for members to use providers and procedures associated with the plan. |
| Medicaid | State programs (with federal matching funds provided by Social Security under stipulated conditions) of public health assistance to persons, regardless of age, whose income and resources are insufficient to pay for health care. |
| Medicare | Federally sponsored programs under the Social Security Act that provides hospital benefits, supplementary medical care, and catastrophic coverages to elderly persons. |
| Medicaid | Private insurance products that supplements federal insurance benefits under Medicare. |
| minimum group | Least number of employees permitted under a state law to effect a group for insurance purposes. The purpose is to maintain some sort of proper division between individual policy insurance and the group forms. |
| modeling | Process of establishing interrelationships between important entities of a system, expressed in terms of goals, performance criteria, and constraints. Entities are described by attributes (i.e., patient age, sex, income, and insurance coverage are attributes). |
| model validation | Process of determining that the model represents the real system. |
| model verification | Process of determining that the model executes as designed. |
| physician's expense insurance | Coverage that provides benefits toward the cost of such services as doctor's fees for surgical care in the hospital, at home, or in a physician's office, and X-rays or laboratory tests performed outside of a hospital. (also called regular medical expense insurance). |
| point-of-service program (POS) | Health care delivery method offered as an option of an employer's indemnity program. Under such a program, employees coordinate their health care needs through a primary care physician. |

**E-SYSTEMS**

| Term | Definition |
| --- | --- |
| **precertification** | Utilization management program that requires the individual or the provider to notify the insurer prior to a hospitalization or surgical procedure. The notification allows the insurer to authorize payment, as well as to recommend alternate course of action. |
| **preexisting condition** | Any physical and/or mental condition or conditions of an insured that exist prior to the effective date of coverage. |
| **preferred provider organization (PPO)** | Mode of health care delivery through which a sponsoring group negotiates price discounts with providers in exchange for more patients. The sponsor may be an insurer, employer, or third-party administrator. |
| **prepaid group practice plan** | Plan under which specified health services are rendered by participating physicians to an enrolled group of persons, with a fixed periodic payment made in advance by or on behalf of each person or family. If a health insurance carrier is involved, a contract to pay in advance for the full range of health services to which the insured is entitled under the terms of the health insurance contract. Such a plan is one form of health maintenance organization (HMO). |
| **professional standards review organization (PSRO)** | Organization responsible for determining whether care and services provided were medically necessary and meet professional standards regarding eligibility for reimbursement under the Medicare and Medicaid programs. |
| **proration** | Modification of policy benefits because of a change in the insured's occupation or the existence of other insurance. |
| **prospective payment** | Payment of a lump-sum benefit to an institution for care of an insured based on predetermined amount correlated with diagnoses. |
| **reasonable and customary charges (r & c)** | Amounts charged by health care providers that are consistent with charges from similar providers for identical or similar services in a given locale. |

**E-SYSTEMS**

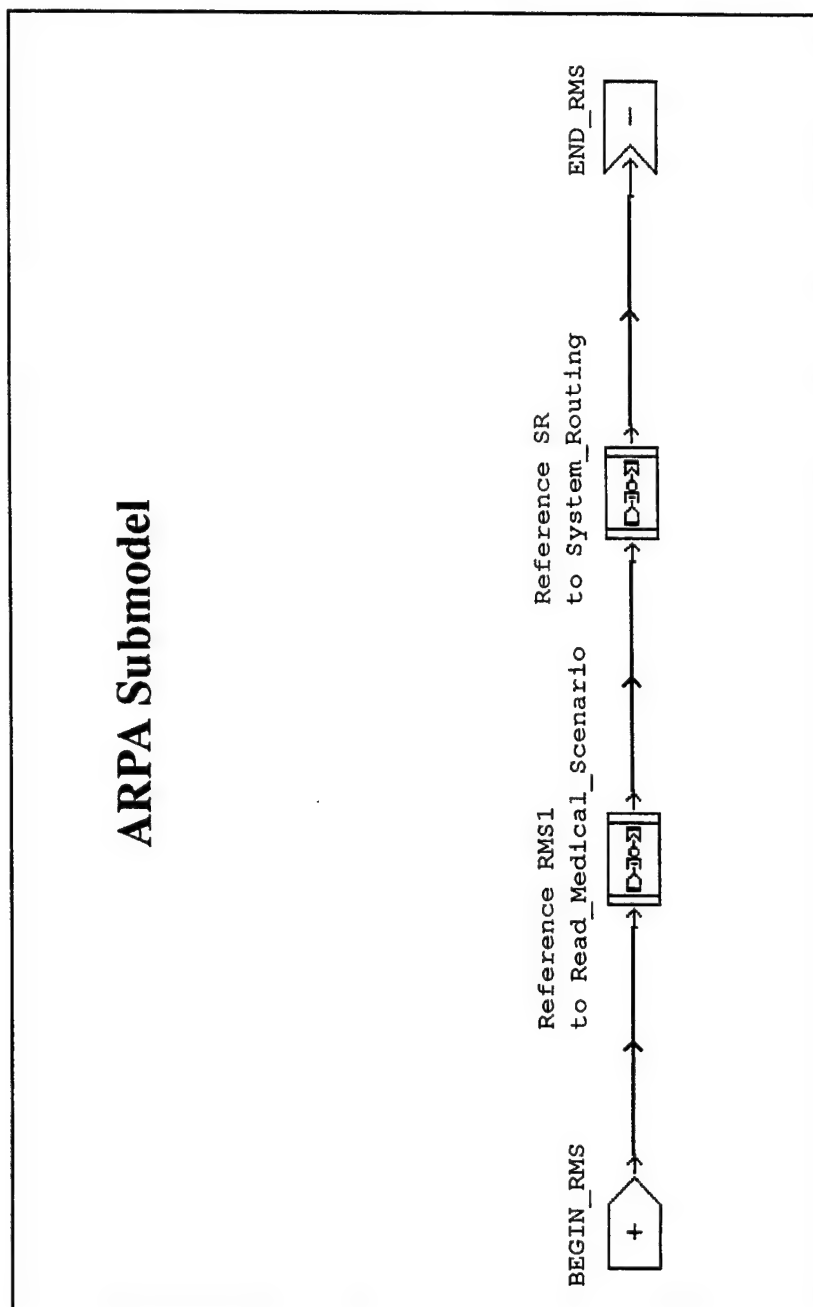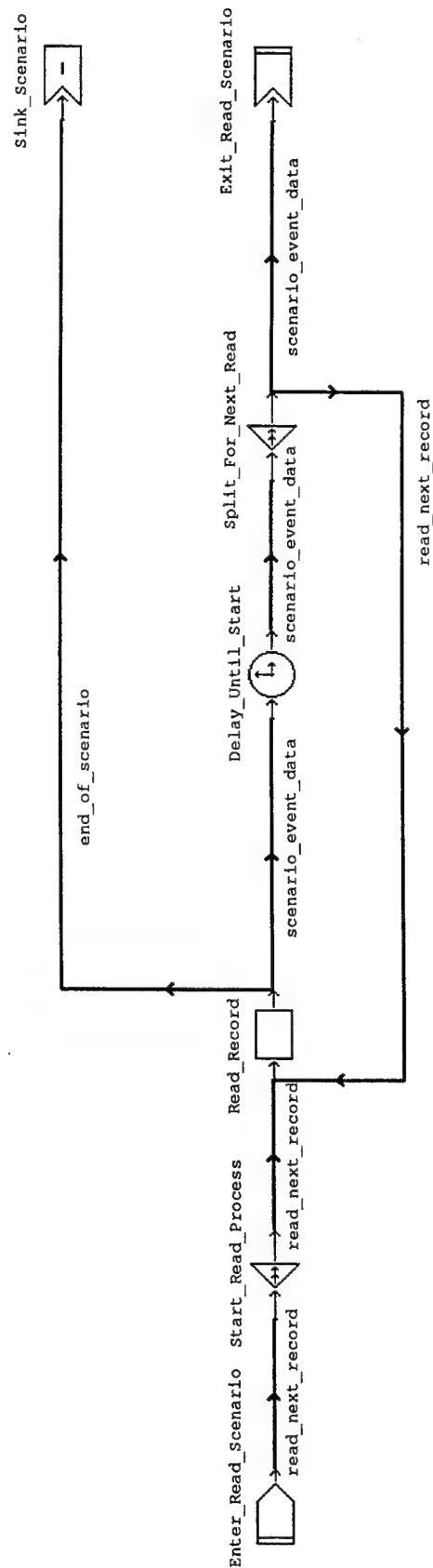| Term | Definition |
|------|-----------|
| rehabilitation | Process and goal of restoring disabled, insured patients to maximum physical, mental, and vocational independency and productivity commensurate with their limitations. It is achieved by identifying and developing residual capabilities, job modification, or skills retraining. Also a provision in some long-term disability policies that provides for continuation of benefits or other financial assistance during the rehabilitation period. |
| risk | Probable amount of loss foreseen by an insurer in issuing a contract. Also person insured or the hazard insured against. |
| self-administration | Situation whereby a group policyholder maintains all records and assumes responsibility regarding insured patients covered under its insurance plan, including preparing the premium statement for each payment date and submitting it with a check to the insurer. The insurance company, in most instances, has the contractual prerogative to audit the policyholder's record. |
| self-insurance | Program for providing group insurance with benefits financed entirely through the internal means of the policyholder, in place of purchasing coverage from commercial carriers. |
| senior citizen policy | Contracts insuring persons 65 years of age or more. In most cases, these policies supplement the coverage afforded by the government under the Medicare program. |
| short-term disability income insurance | Form of health insurance providing benefits only for loss resulting from illness or disease, by excluding loss resulting from accident or injury. |
| Social Security freeze | Long-term disability policy provision which establishes that the offset from benefits paid by Social Security will not be changed regardless of subsequent changes in the Social Security law. |
| state insurance department | Administrative agency within a state established to implement the provisions of its insurance law and to supervise within the scope of this law activities of insurers operating within the state. |
| substandard insurance | Insurance issued with an extra premium or special restriction to those persons who do not qualify for insurance at standard rates. |

**E-SYSTEMS**

| Term | Definition |
|---|---|
| substandard risk | Person who cannot meet the normal health requirements of a standard health insurance policy. |
| surgical expense insurance | Health insurance policies that provide benefits toward the physician's or surgeon's operating fees. Benefits may consist of scheduled amounts for each surgical procedure. |
| surgical schedule | List of maximum amount payable by an insurance policy for various types of surgery, with the amount based on the severity of the operation. |
| third party administration {administrator} (TPA) | Method by which an outside person or firm, not a party to a contract, maintains all records regarding the persons covered under the insurance plan. Entity also may pay claims using the draft book system. |
| triage | Process of determining the level of severity of a patient condition and urgency of care needed. |
| total disability | Generally, a disability that prevents insured from performing all occupational duties. The exact definition varies among policies. |
| underwriting | Process by which an insurer determines whether or not and on what basis it will accept an application for insurance. |
| uninsurable | High-risk persons who do not have health care coverage through private insurance and who fall outside the parameters of risks covered as a result of standard health underwriting practices. |
| waiver (exclusion endorsement) | Agreement attached to the policy and accepted by the insured that eliminates a specified preexisting physical condition or specified hazard from coverage under that policy. |
| white box approach | Simulation approach that implies the system can be described by mathematical relations, physical laws, etc. and the input-output relations are based on factual knowledge of the internal structure of the system. |
| workers' compensation | Liability insurance requiring certain employers to pay benefits and furnish medical care to employees for on-the-job injuries, and to pay benefits to dependents of employees killed by occupational accidents. |

**E-SYSTEMS**
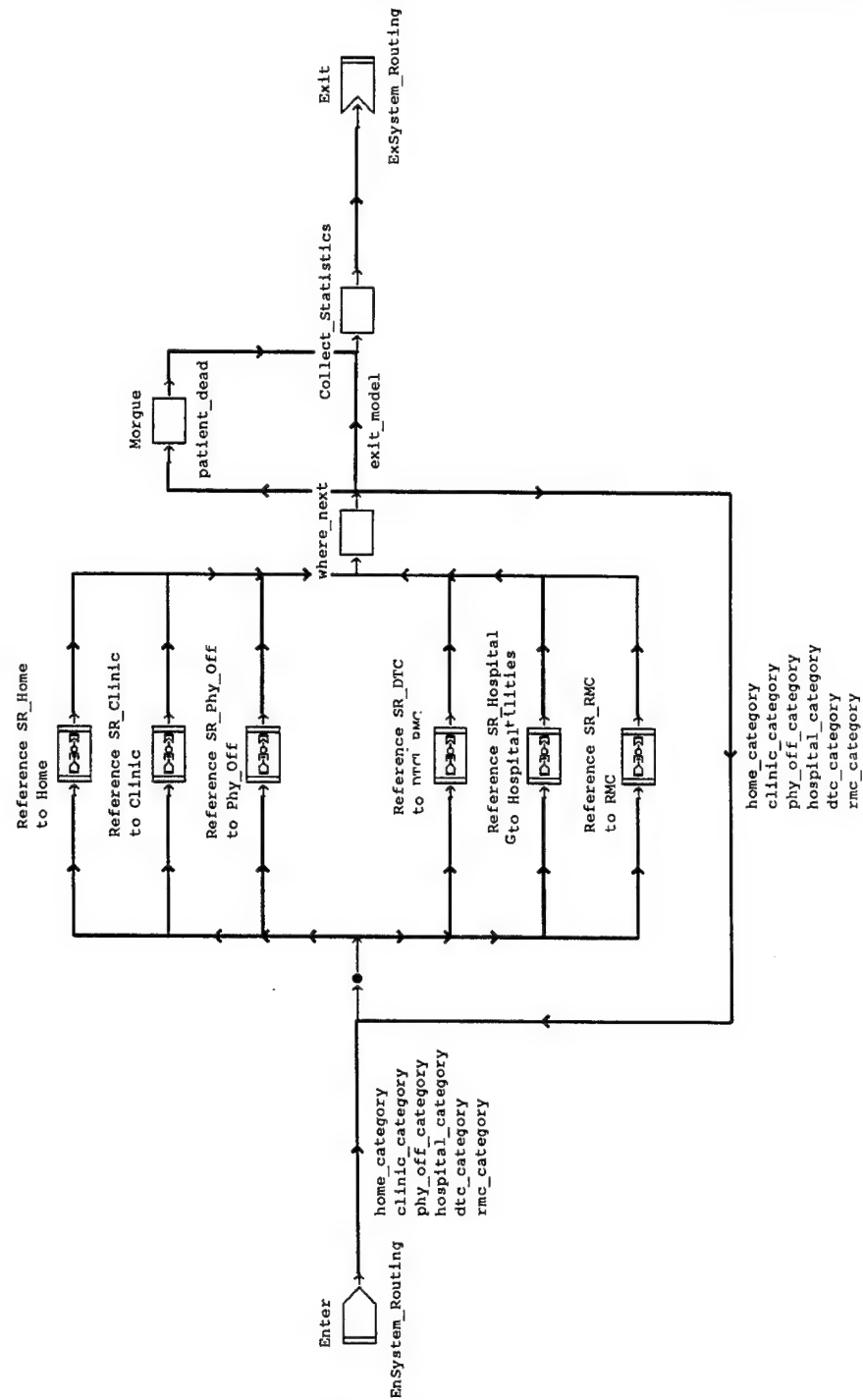
# Appendix C: Submodel Schematics

This appendix graphically displays the architecture of each submodel used in the HCES Model. For a textural description of each submodel, see *Section 4: Model Components*.
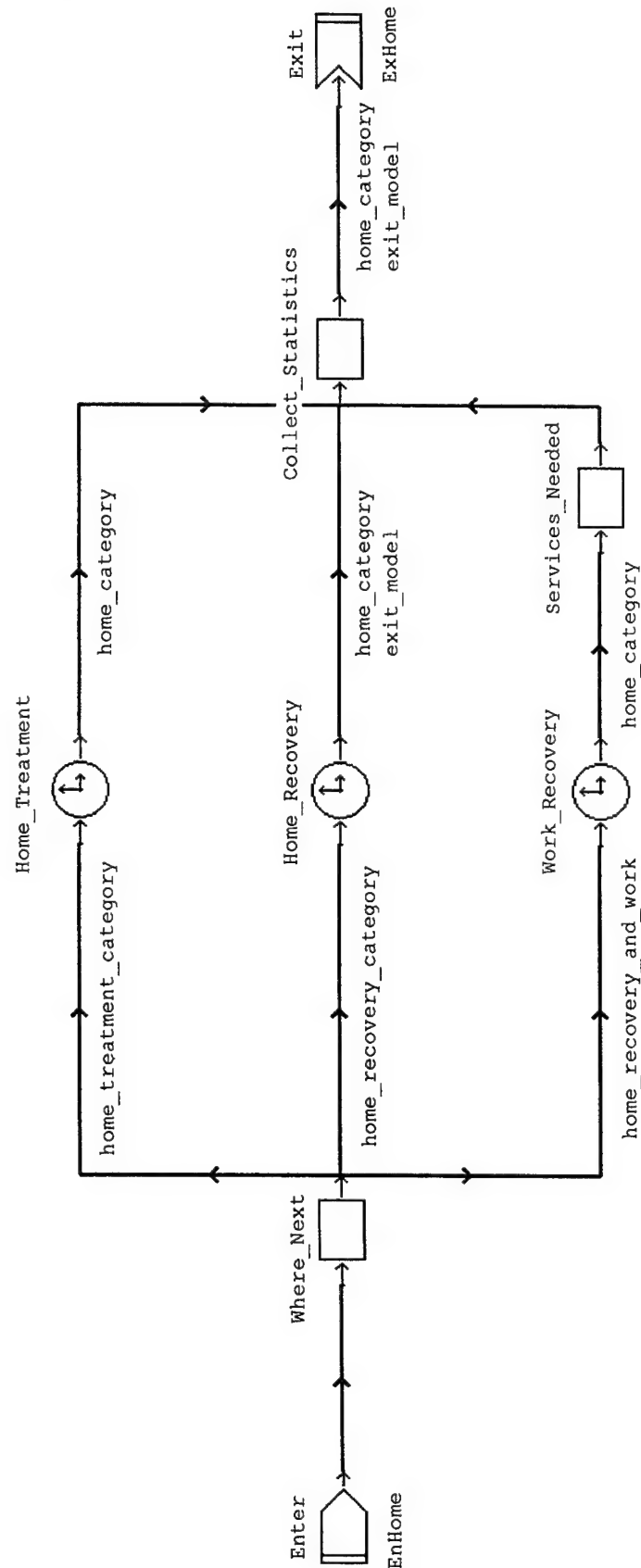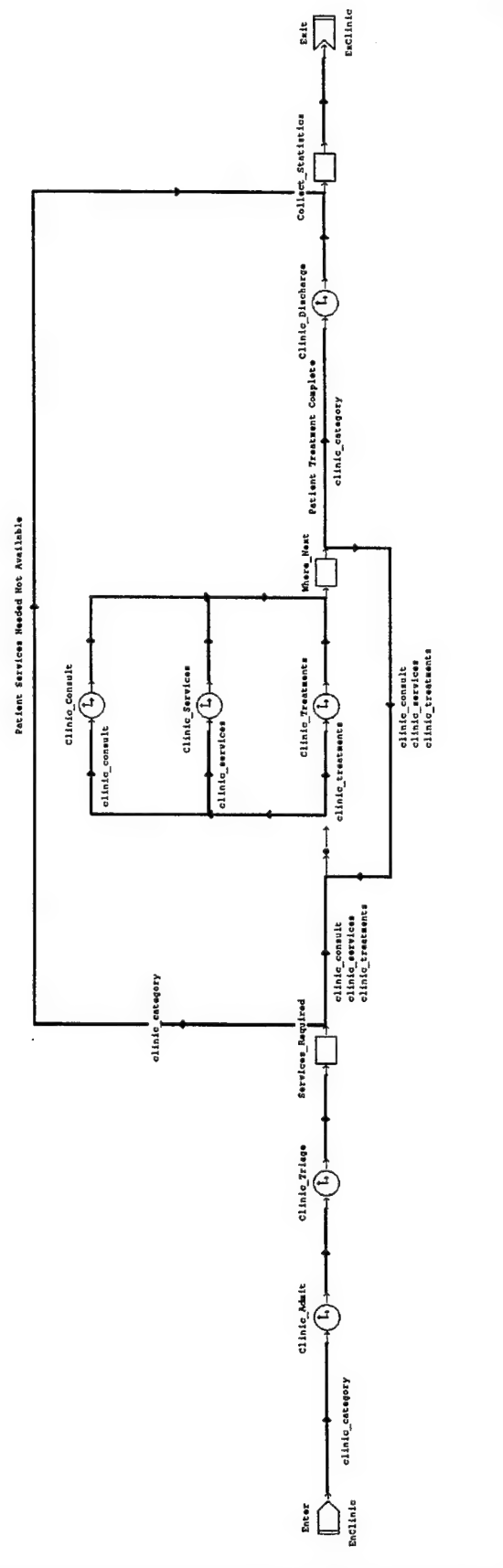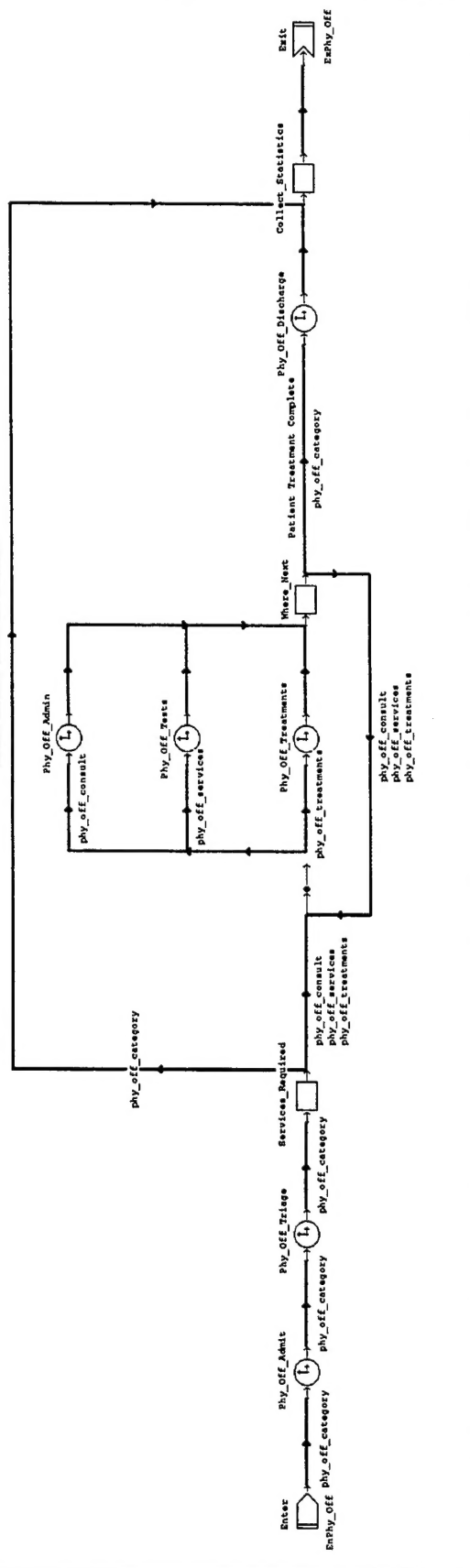
# E-SYSTEMS

## Read Scenario Submodel

**E-SYSTEMS**

## System Routing Submodel

**E-SYSTEMS**

# Home Submodel

**E-SYSTEMS**

# Clinic Submodel

Enter
EnClinic

clinic_category

Clinic_Admit

Clinic_Triage

Services_Required

clinic_consult
clinic_services
clinic_treatments

clinic_category

Patient Services Needed Not Available

Clinic Consult
clinic_consult

Clinic_Services
clinic_services

Clinic_Treatments
clinic_treatments

Where_Next

clinic_consult
clinic_services
clinic_treatments

Patient Treatment Complete

Clinic_Discharge

clinic_category

Collect_Statistics

Exit
ExClinic

**E-SYSTEMS**

# Physician Office Submodel

**E-SYSTEMS**

# Diagnostic & Treatment Center Submodel

Enter
EnDTC

dtc_category

DTC_Admission

dtc_category

DTC_Triage

dtc_category

DTC_Initial_Exam

dtc_category

Services_Required

dtc_category

dtc_admin

Service_Fork

patient service needs are not available

dtc_category

DTC_Administration

dtc_admin

DTC_Services

dtc_services

DTC_Treatments

dtc_treatments

Service_Join

DTC_Discharge

Exit
ExDTC

**E-SYSTEMS**

# Hospital Submodel

# E-SYSTEMS

## Regional Medical Center Submodel